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THE ELECTRICAL AGE

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Making a Small Electric Plant Pay

By S. O. Newton

At the time at which the writer took charge of the plant of the Weatherford Water, Light & Ice Company, its financial condition was such that interest on the bonds had not been paid for a long time. The plant had not had the benefit of good engineering practice, although the electrical equipment was with the art in its day. The subsequent management, however, apparently had not been good, as no progress had been made in modern methods.

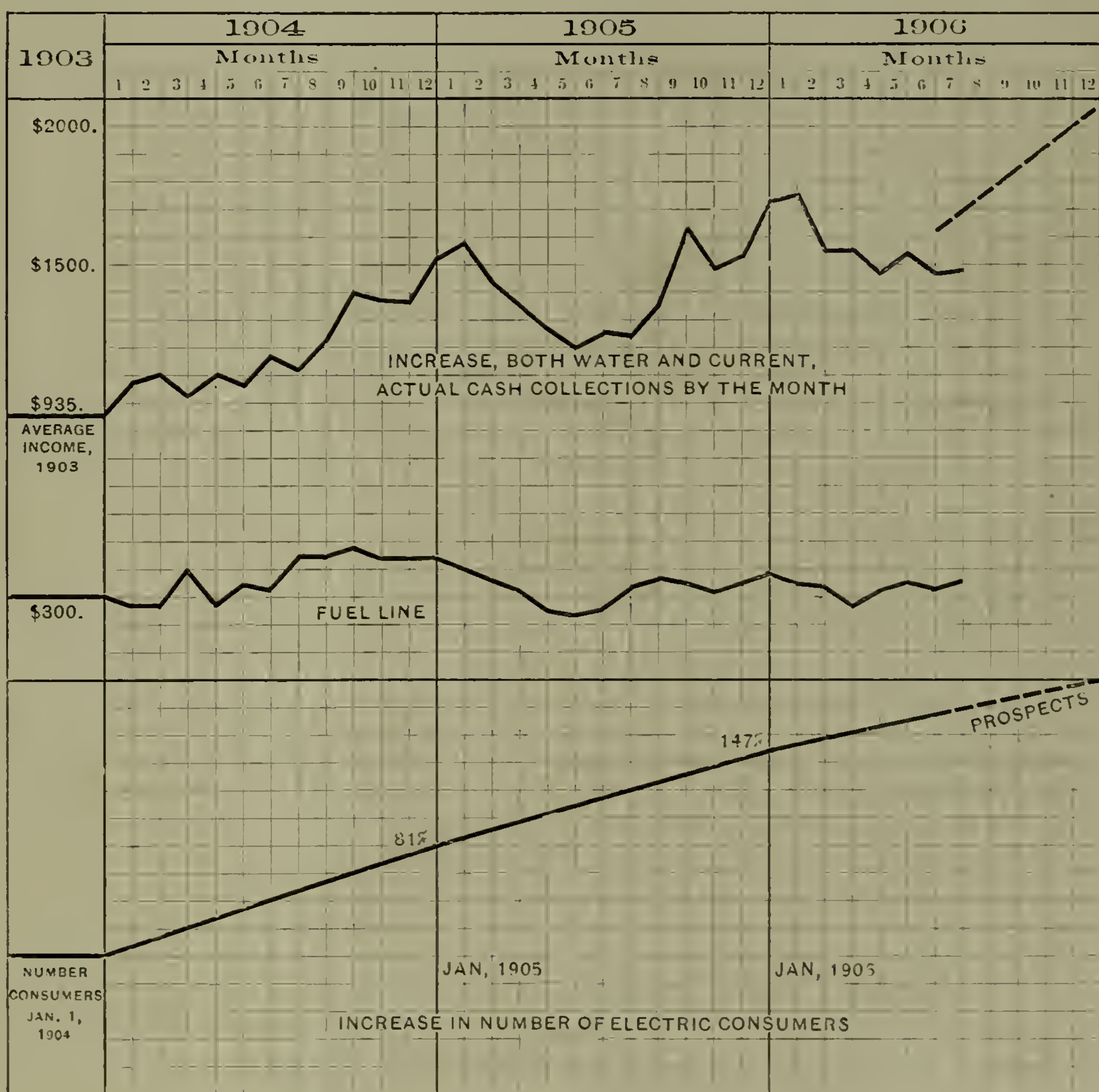
The plant had a combined electric, water and ice business, though the last-named had been abandoned. The electrical equipments were running on throttle, not on the governors.

The town people were disgusted and the company had little load. We found $65 in the bank and a tax charge of $363 that should have been paid a month before for the taxes of the previous year. Repairs were begun at once on the plant, no attention being paid to efficiency, as the sole object was to keep running. We did not know whether it would pay, but we were simply feeling our way. The writer busied himself with a monkey wrench, and on one occasion wheeled coal, patched the belts, and did such other things as an ordinary station man would have done.

With the improvement of the service the people caught the inspiration of our purpose and the demand for current came. The engine governor was placed in commission, some regulation was secured, and in due time a twenty-four-hour service was furnished. A thousand dollars were spent on the engines, providing a new piston, piston rod, valves and rocker arms. When the engine repair work was finished, every moving element of the engine was new.

The first year the increase in number of consumers was 81 per cent.; in two years it was 147 per cent., with a 75 per cent. increase in electric income in two years. With the growth of business there was a demand for better help, which of course meant an increase in wages, and that a larger maintenance expense was necessary.

An obsolete system of accounting was found to be in use, and this was continued for five months after the writer took charge. Then the system recommended by the committee on a standard system of ac-



CURVES SHOWING INCREASE OF REVENUE, FUEL CONSUMPTION, AND INCREASE IN NUMBER OF ELECTRIC CONSUMERS OF THE WEATHERFORD (TEXAS) WATER, LIGHT & ICE COMPANY. IT IS INTERESTING TO NOTE THAT THOUGH THE NUMBER OF CUSTOMERS AND REVENUE HAVE MATERIALLY INCREASED, THE FUEL CONSUMPTION HAS REMAINED PRACTICALLY THE SAME.

counts, at the Niagara Falls convention of the National Electric Light Association, in 1901, was adopted With the old method, the office records furnished no intelligent guide in developing the business, and for lack of such comparative data the first year's work was done practically by intuition. The income of the company in the previous year was $10,000 for water and electric service. The income during the first year of the writer's management was over $14,000, and a trifle over $16,900 during the second year; the income for ten months of the third year was $15,501.88, which would bring the total income for the year up to about $20,000. The percentage of gross operation for water and electric service was 69 per cent. the first year and 72 per cent. the second year, the slight increase being due to increased wages.

Immediately on taking charge of the property the writer reduced the meter rates 10 per cent. without public announcemnt to that effect, the customers not being advised until they received their bills a month later. We immediately adopted the methods of the larger companies in dealing with customers, treating all of them in an equitable manner. There were a number of meters in town, but for the most part the patrons were on flat rate. As quietly as possible, the flat-rate customers were induced to adopt meter service, a few being changed over at a time to avoid confusion. During the first year we spent $600 for meters and $1,400 the second year, and are still buying.

In December, 1903, when the writer took charge, the meter rate was 20 cents per kilowatt-hour, which was at once reduced to a sliding rate from 18 cents to 12 cents, according to conditions, such as length of hours, time of day, and class of service. The minimum rate was $1 and in some cases $2. The average return last year was 12.9 cents per kilowatt-hour. The income of the water plant is $7500 a year. Our progress gave the owners promise that there were possibilities of development in this plant, and they were consequently ready to buy new apparatus.

We spent $3000 the first year in the repair of the plant, and a like sum the following year; during the present year we are spending about $10,000 on alternating-current installation.

The town of Weatherford is the county seat and extends one mile in each direction from the court house, so that it covers an area of about four square miles, and the population, about 5,000, is consequently quite scattered. Through large sections of the town the houses are placed on corners, and we have to cater to the numerous one-story cottages.

Shortly after the writer took charge the city contracted for seven multiple-arc lamps at $120 per year, outage deducted (six ⅜-inch carbons, and one ½-inch carbon), operating on 70 per cent. of efficiency. The yearly rate figures out about 7 cents per kilowatt-hour for this service. Our current cost the first year was 7.3 cents per kilowatt-hour, and 9.5 cents the second year. As will be seen, then, the service to the city is given at a loss, but the load lasts for twelve hours and helps to improve the load factor. During our first two years' growth we got along with a ton of copper and a carload of poles. About twelve tons of copper were already up.

When the writer first came to the plant it was amusing to see the "floor" wondering when it was best to start the lights, even if it was quite dark. Our peak would be about 90 amperes, at perhaps a 20 per cent. load factor, running from dark to sunrise. Our load now is 450 amperes at the peak, with twenty-four-hour service and a load factor of from 40 to 48 per cent.

The working force comprised a collector, engineer, fireman and helper, and a water-plant man. The local wireman did such wiring as was required and placed the meters. The old equipment consisted of one 9-inch x 14-inch Buckeye engine operating at 250 revolutions per minute with 100 lbs. pressure, belt connected to two 20-KW Edison bi-polar generators. The Edison machines were made in 1887, at which time the plant was installed.

One belt had patches the thickness of the belting leather, and when those patches ran over the pulley, you could see the light in the corner barber shop, and for that matter all over the town, giving a characteristic flicker of "belt splicing." The armature had been rewound and was riding on both pole pieces because the rewinding was a poor job; a week later it was short-circuited and we were obliged to insert a splicing. In due time the armature was replaced with a new one, and a new belt was also bought, the bank balance and the fuel in store being thoughtfully contemplated meanwhile.

An 8-inch x 12-inch Russel engine running at 305 revolutions per minute was direct connected to a 4-pole, 110-volt, 25-KW General Electric machine which was installed in 1901 for running the "fan circuit." The outboard bearing was found to be ¼ inch low and not lined in the direction of its drive. The steam was chasing through the holes of the core supports in the piston.

One of the things not formerly done in the station was compensating for the peak-load line loss. At first we used the old primitive indicators and kept on the "dot." Now we use voltmeters; and we compensate about twenty volts to get good light on the peak; near the station we use 120-volt lamps, and a mile away 100-volt,—not good regulation. However, we now have 2 per cent. regulation on alternating current.

In the station equipment was found a feed pump which the help said was "shot to pieces" and was not in use. As it was a power pump the writer believed it to be worth something, and, for an example, it was overhauled at a moderate expense and is now in use almost continuously. If it would have cost as much to overhaul this pump as a new one would have cost, the writer would have preferred to have done it for the example to the help.

The engines were located about 75 feet from the boilers, and the steam piping was found to be inadequately covered. The knock of the engines was something terrific; they could be heard three blocks away.

In the second year we continued the repairs, and began the payment of bond interest which had long been defaulted; in fact, the writer is not aware that any truly earned interest was ever paid in the plant's history; this second year, $1800, or 3 per cent. of the defaulted interest, was paid.

In January, 1904, the plant had no motor load aside from the fan load in summer, with the exception of a ½-H. P. motor, which was occasionally used by a physician for driving a static machine. We soon put two small motors in one printing office for operating job presses, one 2-H. P. motor in another printing office, and one in a third printing office, one in a bottling works, and two in bakeries.

Our water pumping was done by a Cook steam-heated (sucker rod) 10 inches x 36-inch stroke, which was replaced in February, 1906, by a pump driven by a 17-H. P. Westinghouse belt-connected motor. It effects a saving of $1800 per year.

We have now new alternating current equipment nearly ready to start, and a nice increase of load in prospect.

A Card Record System for Central Station Apparatus

By H. N. MÜLLER, of the Allegheny County Light Co., Pittsburg

THE apparatus of a central station manager, such as house meters, station transformers and devices for the transformation, metering or conversion of current into either power or light, unlike hardware or grocers' stock, which is usually kept upon shelves or in storage in places accessible for ready inventory, is scattered throughout the length and breadth of the territory served by the central station system. To properly follow up such apparatus to avoid loss through improper records, destruction, or by theft, becomes a difficult matter, which increases with the individual articles to be recorded.

The central station manager of today often finds himself with a system which is the result of the consolidation of smaller systems, which, in turn, often consisted of still smaller urban and suburban plants. The records for apparatus of these first owners may consist of anything, from the vest-pocket memorandum to a quite comprehensive collection of data. Only too often, owing to the limited number of such properties at the beginning, the records consist of indifferent book notations supplemented by the memory of the lineman or inspector on the job.

For hunting up and making a record of each piece of such apparatus, as well as adding to it all such additional stock as is required from time to time, and for following up the location, performance, efficiency and maintenance of each, a card record system, which has exceeded the expectations of the originator, is given here.

After the various forms had been developed, a general inventory was taken by a patrol of all the lines of the operating company and reports were made of the serial number, size and make of all apparatus found, whether in use or not, and the report was then sent to the department of records, where it was transcribed to the cards. Other forms were developed for insuring the regular entry of all additional stock purchased, as well as adding information concerning all old material, by the following method:—

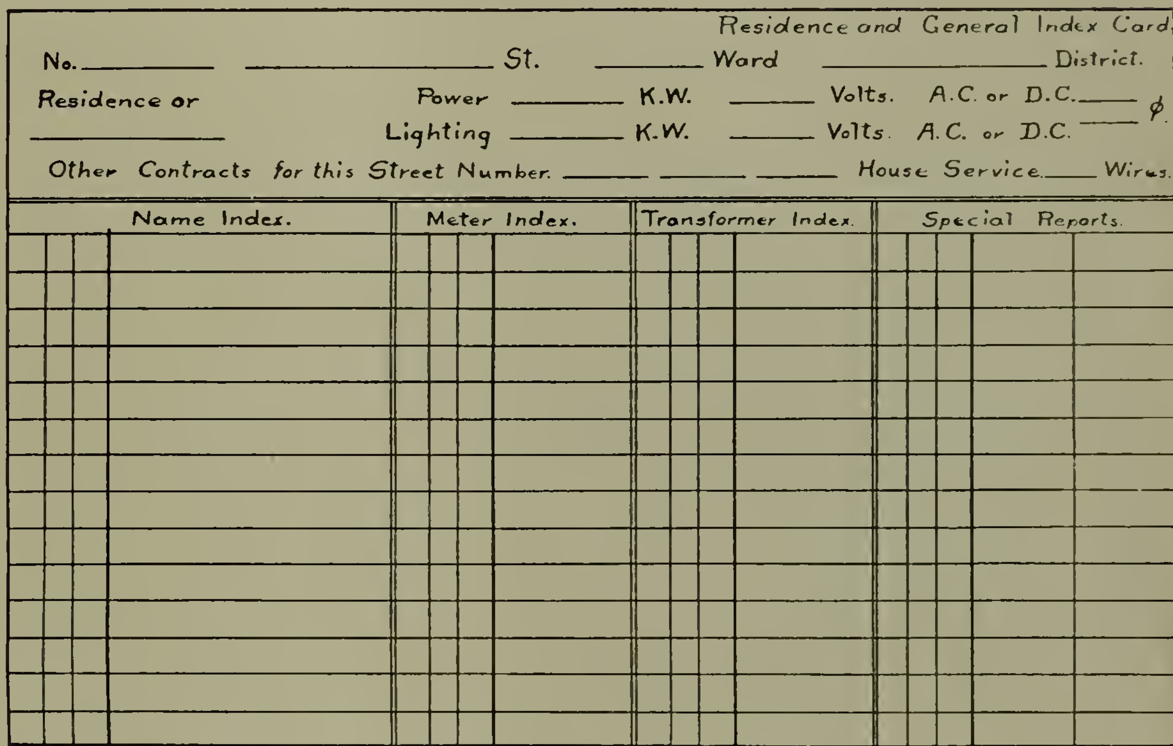

Residence and General Index Card
No. ____ ____ St. ____ Ward ____ District.
Residence or ____ Power ____ K.W. ____ Volts. A.C. or D.C. ____ ϕ.
Lighting ____ K.W. ____ Volts. A.C. or D.C. ____
Other Contracts for this Street Number. ____ ____ ____ House Service ____ Wires.
Name Index. | Meter Index. | Transformer Index. | Special Reports.

FIG. 1.—A RESIDENCE AND GENERAL INDEX CARD.

All apparatus purchased must be passed by the testing engineer or other authorized department, for approval or rejection based on the performance of the apparatus as compared with the specifications on which it was purchased. Should the apparatus be approved, it is immediately given a number, which is preferably stenciled into a metal name-plate or on a convenient and conspicuous part of the apparatus proper. This point is mentioned with a view of cautioning against numbering by means of painted letters or figures, which are found to be of short life, easily

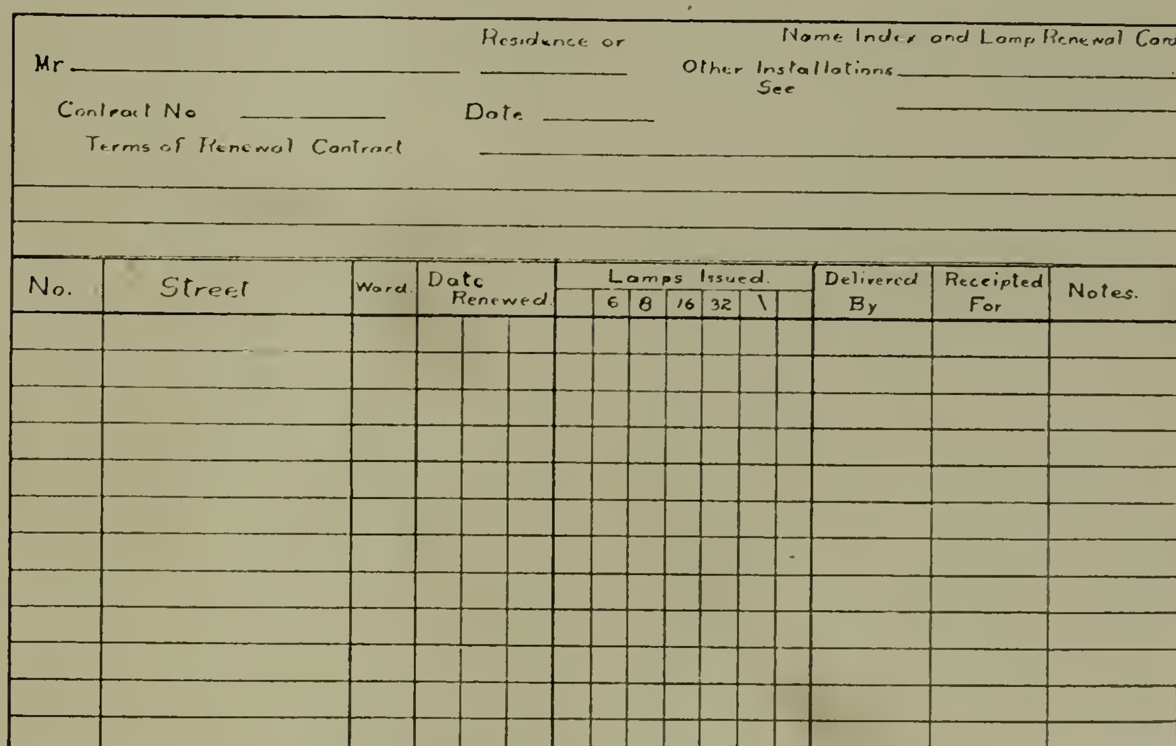

Name Index and Lamp Renewal Card
Mr ____ Residence or ____ Other Installations ____ See ____
Contract No ____ Date ____
Terms of Renewal Contract ____
No. | Street | Ward | Date Renewed | Lamps Issued: 6, 8, 16, 32 | Delivered By | Receipted For | Notes.

FIG. 2.—A NAME INDEX, AND LAMP RENEWAL CARD.

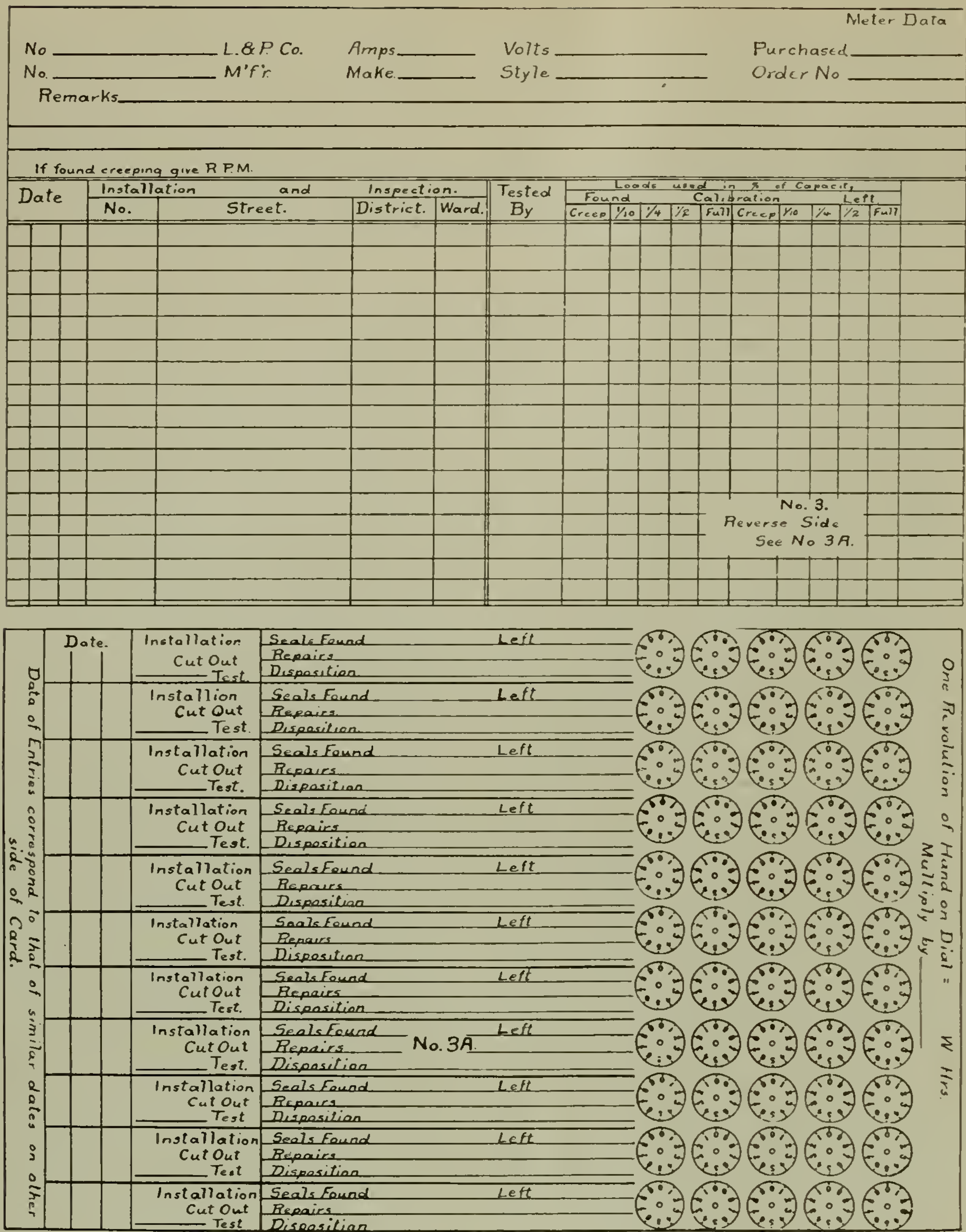


FIG. 3.—FACE AND REVERSE SIDE OF A CARD FOR METER DATA.

erased and usually painted over while the apparatus is in service. For this purpose it is advisable that the operating company develop an escutcheon plate with the name of the company and a blank space for the serial number. This can be gotten up in a very neat and permanent form and of such size as to permit of its use on various forms of meters, transformers, arc lamps, Nernst lamps, fan motors, and the like, without defacing or marring the instrument from an artistic point of view.

At the time the number is attached to the approved apparatus, it is desirable that a certificate with the data of test be issued in duplicate; this certificate should supply the information called for on the various cards to be described later, as well as indicate by blank spaces the additional information to be filled in by the various parties making the installation in service. The original certificate of test should be enclosed in a protecting envelope bearing upon its face such data as voltage, capacity, and the like, to determine the adaptability for any work for which it may be desired, as well as the instructions to forward the certificate to the record department when properly filled out. The duplicate is sent by the tester to the record clerk, who is thereby notified that the apparatus has been approved on a certain date and on a given order number. The card is accordingly made out and placed in the store room stock files, where it is kept until the return of the original showing the place and date of installation and data as called for on the separately described cards. The card is then taken from the store room stock files and filed according to the prospective index of each.

From the above it will be seen that a card is made up for every piece of apparatus at the time of its acceptance from the manufacturer. This card, with a card for every occupant or consumer, as well as for every installation by house number made at the receipt of the contract, together with the data cards, gives us the series of cards, which are described here.

The residence and general index card, shown in Fig. 1, bears in the upper left hand corner the street and number at which the given installation is made. These cards are filed in the following divisions and subdivisions:—First, all cards of a given district or borough; second, into various wards of the borough; third, alphabetically under the various streets, and finally in order of their house number.

On the top of the card is given what might practically be called the fixed information for a given place, such as the character of the establishment, the use made of current, the quantity in kilowatt, the voltage, alternating current or direct current, single or polyphase, and whether the house is wired for two or three-wire distribution. Attention is also called to other cards should there be other contracts under the same street number, a possibility in the case of apartment houses.

Under "Name Index" is noted the name of the occupant reported at the various periods of inspection or installation opposite the date of the report. Under "Meter Index" is placed the date of inspection or installation and the company's serial number of the meter installed or of the one found already in service. Similar information is given under "Transformer Index." Under "Special Reports" is noted the date, file, and page number of any special reports or correspondence bearing on complaints of unsatisfactory service, excessive bills or cut-out for non-payment, theft of current, or any other information of value.

From this card can be had the name of the occupant, the number of the meter and of the transformer reported at any given date, giving a close index to any card for other information, as follows:—

Having the name of the occupant of a certain address, a card of that name, filed alphabetically, should be found. This card is known as the index and lamp renewal card, and is shown in Fig. 2. It gives the "Contract Number," "Date," and "Terms of Lamp Renewal Contracts," and also refers to other installations under the same name. This card was designed primarily for a cross index to the location of a customer should the name only be known, but the additional space was used to good advantage as a record of the lamps renewed to a given customer, and also for the addresses or house number at which the lamp deliveries were made at the various times recorded.

Under "Street and Number" are shown the various localities at which a given customer has been found, opposite the date of inspections or lamp renewals for a period of time depending upon the life of the card system. From this street and number reference can be had back to the first card described.

Under "Date Renewed' are shown the number of lamps of each candlepower issued opposite the respective date, the name of the company's employee making the delivery, and the name of the party receipting for the lamps, with a margin for special remarks or reference to other reports.

From the first or "General Index" can be had the number of the meter at a given installation and given date. The card covering this can be found filed according to the operating company's numerical order of the instrument. This card, which is shown in Fig. 3, is printed on two sides. On the face is shown in the upper left-hand corner the operating company's serial number and directly below the manufacturer's number: other fixed data, such as amperes, volts, make, style of the instrument, date of purchase, the order number, etc., are given, with room for remarks.

Beginning at the left is shown in order the date of installation or inspection of the meter, the house number, street, district and ward in which it is installed, the name of the inspector making the test or installation, the results of the test at the various loads (both before and after, if repaired and calibrated), with a margin for other possible notes. On the reverse side of this card, and corresponding to the same date of entry as that on its face, can be found the details, such as the reason for the visit of the company's employee (whether for the purpose of installation, removal or test), and further on is shown the condition of the seals of the meter as found, also as left by the inspector on this trip. The card also indicates the repairs made, which, in the case of numerous entries, can be shown by symbols representing various operations.

Under "Disposition" should be stated whether the instrument was left in service, scraped, returned to the manufacturer or otherwise disposed of. Further to the right is shown a fac-simile reproduction of the dial at the time of the visit. This

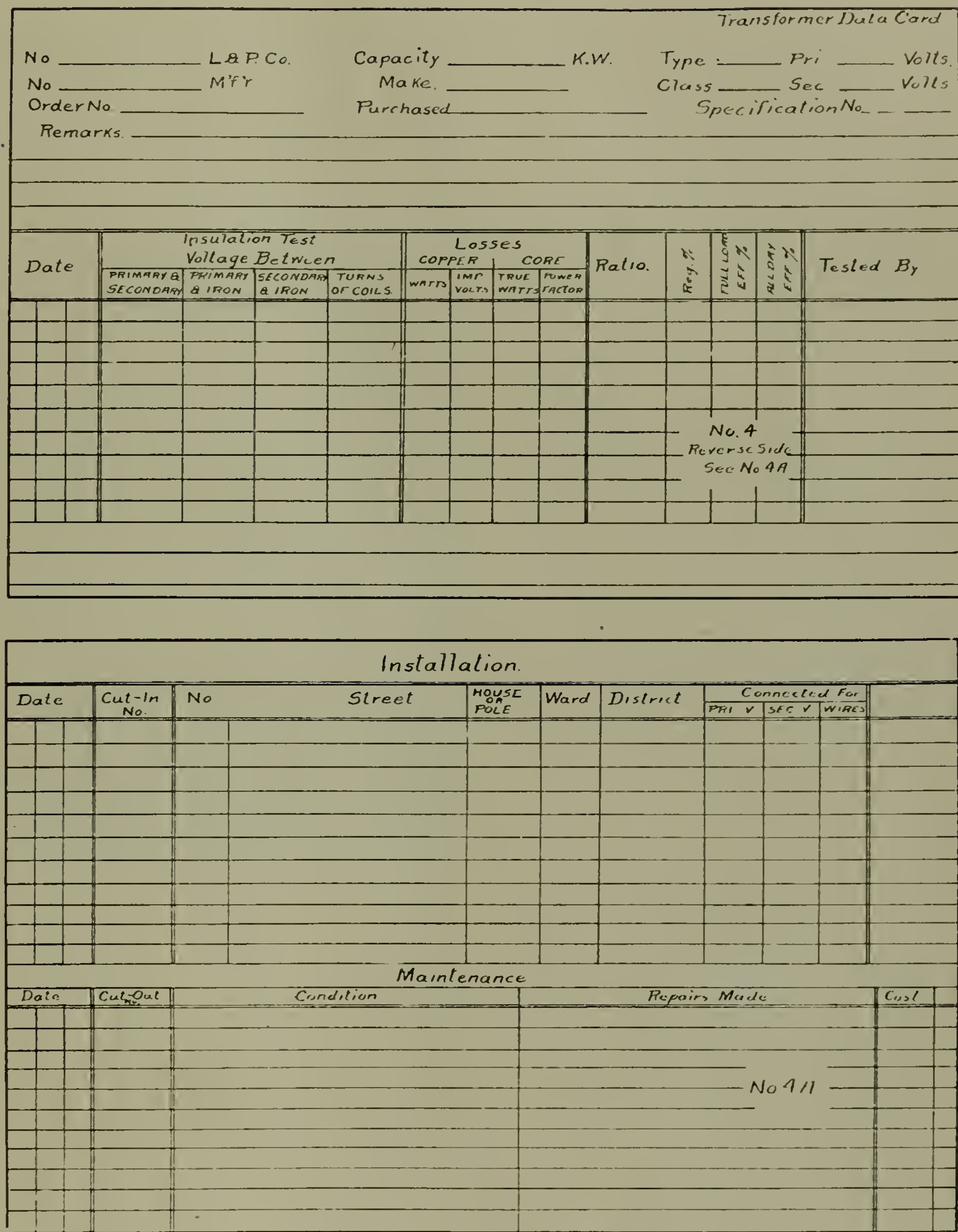


FIG. 4.—FACE AND REVERSE SIDE OF A TRANSFORMER DATA CARD.

is preferred to a reading in figures, on account of the liability of error on the part of the meter reader. A dial picture has special value where hands become shifted and the error of reading dates back to some time in the past, a solution for the incorrect reading often being found by comparing the relative position of the hands as reported at some prior date. On the extreme right is to be shown the value of the smallest or right-hand dial in watts or kilowatt-hours, also the dial constant by which the reading is to be multiplied.

The transformer data card, shown in Fig. 4, is also filed and indexed according to the operating company's serial number. Each transformer approved for service has a test certificate or card as described in the foregoing similar to that for the meters. A card is made out immediately after notification is made by the department approving the apparatus for stock, and is kept in the store room stock file until the return of the duplicate certificate to the record department with the papers authorizing the connection or installation. The data called for in Fig. 4, as described in the following, is then entered and the card takes its place in the order of its serial number, which is shown in the upper left-hand corner. In addition are given such fixed data as the serial number and name of the manufacturer, the capacity, type, class, primary voltage, secondary voltage, date of purchase, order and specification number, with room for remarks.

In the vertical column beginning at the left is placed the date on which the test was made and its results, the insulation test between the various windings and the parts of the apparatus usually tested, the losses of transformer, copper and iron, the ratio between the respective windings, the regulation or unity or other power factor, the full-load efficiency (which, of course, can be calculated from the other data), and the name of the tester.

On the reverse side of the card is given, in the upper half, the date of installation, the number of the order authorizing it, the street and house number at which the transformer may be installed, also whether installed in the house or on the pole, the ward and district, the voltage of primary and secondary, and the method of connection, whether for two or three wire, the blank following being for notes in case of special voltage or phase. In the lower half is the date and number of the order authorizing the cut-out or removal, the condition of the transformer, the repairs made and their cost.

A record of the location of the transformer is, of course, necessary to properly keep a record of the apparatus, and the card shown in Fig. 4 serves as a cross index to the "General Index Card" first described. The transformer card is thus linked to the rest of the card record system, and means are provided for obtaining any information from the manufacturer or any department of the operating company having anything to do with the purchasing, installing, or repairing of the transformer or data relative thereto.

The history of a transformer, such as the original efficiency, performance in operation, ageing and depreciation, the cost of time and material used for repairs, and the like, are of service in determining the merits of relative makes and of value to the engineer.

The collection of the maintenance data is accomplished by the means of a shop tag, which can be attached by the employee removing the apparatus, at the time writing thereon the date and cause of removal, etc., or by the stock clerk at the time of its return to him. This tag has spaces provided for additional information called for on the apparatus card described above. This tag is generally represented by the test slip, the duplicate of which it accompanies to the record department. It is of further use in checking the time of employees stated on it with the time charged by them on daily time slips.

The efficiency of the above system, of course, depends upon the accuracy and faithful collection of the information; therefore, all reports and papers relating to the data covered by the system should bear the stamp of that department through which they pass, to show that the information has been made a matter of record. The department is thus an exchange or clearing house to which all other departments contribute and to which they apply for information. The man in charge should be a man of judgment and discrimination; he should see that all forms are properly filled in and forwarded and that only such information is issued as the applicant may be authorized to obtain.

This unit system permits of its extension to include all other transient apparatus.

With regard to the method of filing the apparatus in the order of their number, various refinements can be made use of to further facilitate the system, such as separating transformers of different capacities into series of different numbers, that is, making the 1000-watt transformers in a series of numbers, beginning with 1000; thus, the first one-kilowatt transformer would be 1001, the second 1002, and so on. The first ten-kilowatt transformer would be 10,001, the second 10,002, and so on.

Meters and other apparatus can be classified by voltage or capacity, and by prefixing a letter to the number the manufacturer's name can be indicated, thus imparting to anyone familiar with this key knowledge of the capacity, number and make of the apparatus, as well as permitting the grouping of each capacity collectively in the files.

The use of various tints of paper for each class of work can be carried out to any extent, according to the demands and opportunity for the simplification of the system.

The question of relative expense as against the advantage must be decided in each individual case, depending in a large measure upon the amount of the apparatus and the extent of territory it covers.

Corrugations in Street Car Rails

By H. B. NICHOLS

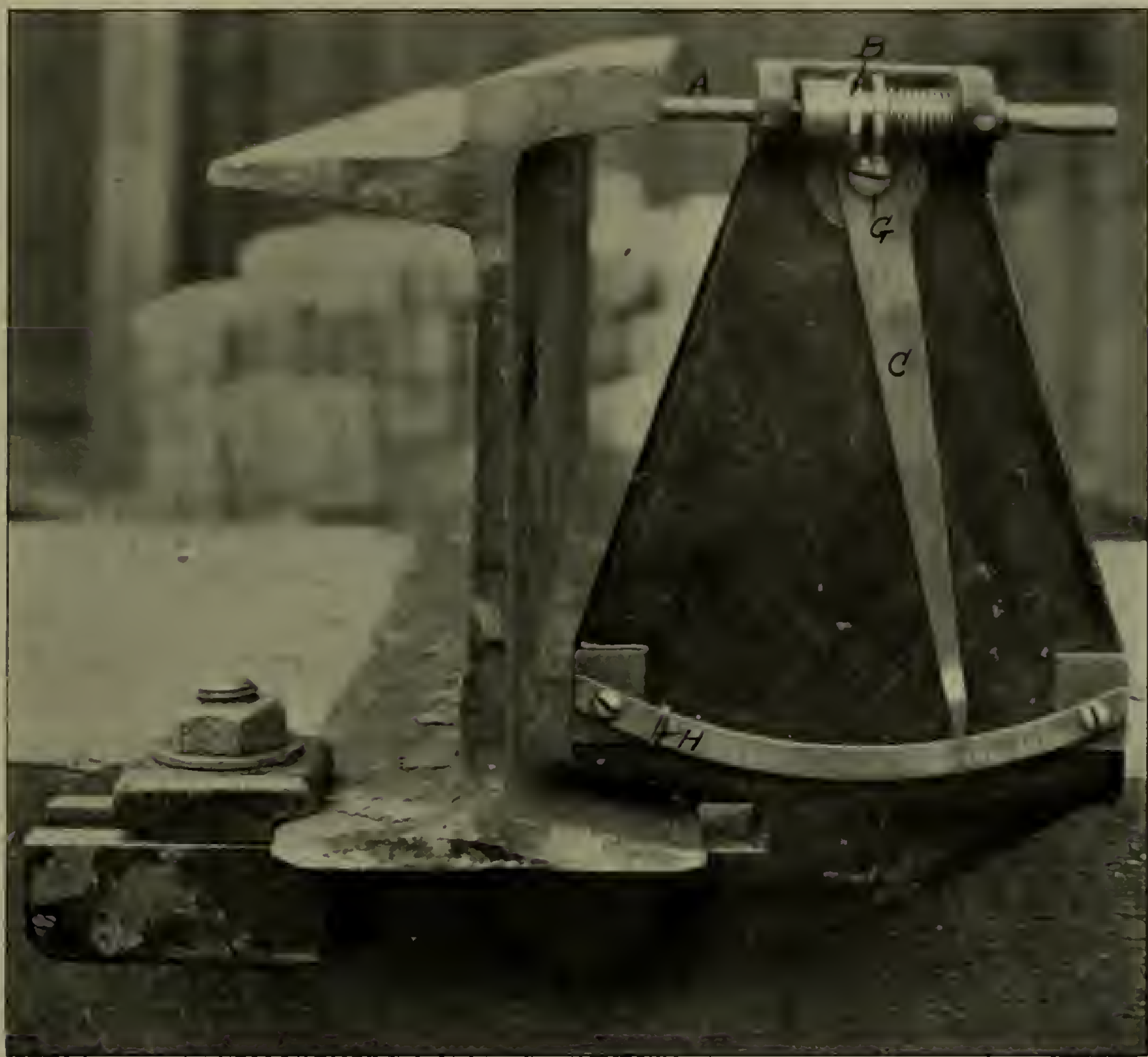
While the subject of corrugations in street car rails is not strictly an electrical one, it is of vital interest to every street railway. The author is engineer of way of the Philadelphia Rapid Transit Company, and is responsible for a number of up-to-date methods in street railway track maintenance.—The Editor.

THE primary cause of corrugations in street car rails, it is assumed here, is vibration, either in the rails or in the entire track structure; that is, the wheels of motor or other power-driven cars have a tendency to skid or slip because of the rapid vibration of the rails, which, by reason of the inertia of the car, the wheels are unable to follow instantaneously, thereby causing friction between the wheels and rail to vary in accordance with the wave length of vibration.

The corrugations may arise from any one of four different causes, namely, the vibration or lateral bending of the web of the rail itself; the rails being loose on their supports; the ties being loose on their foundations; the vibration or movement of the foundation immediately under the track structure.

Which one of these defects or conditions caused the corrugations, can be ascertained by inspection of the head of the rail. Each condition produces corrugations of a different character, not only in length and form, but also with certain other peculiarities difficult of explanation without referring to a case in point.

The writer has several times been asked why these corrugations do not appear more frequently on steam roads, if they are, as he believes, due to vibration. The answer is, in his opinion, that the comparatively loose rail is forced ahead by the great weight of the locomotive in the well-known long wave, and that there is very little slipping in the wheels of



AN INSTRUMENT, DESIGNED BY THE AUTHOR, FOR INDICATING THE AMOUNT OF LATERAL BENDING IN A STREET-CAR RAIL

the trailer cars. The writer has had several letters from engineers of foreign roads, describing their troubles with corrugated rails, and has noted that in the most serious cases the rails were supported by chairs or were provided with some form of a cushion. He thinks a careful inspection would show that there is a slight movement between the rail and its supports.

It has also been called to his attention that on some street car tracks where the rails were extremely loose there were apparently no corrugations. He has found, however, that in many cases the corrugations actually existed, but in such elongated form as not to be apparent from casual inspection. However, a rail flexible enough to produce only these long corrugations would bring other troubles quite as serious, and it would be practically impossible to maintain such a track in any heavily traveled paved street.

The writer has made quite a number of experiments and trials to verify his theory, and would call attention to one case. About five years ago it was proposed to reconstruct a section of double track about 2000 feet in length, using a 90-pound, 9-inch girder rail laid on ties on a gravel base. When the excavation was made, however, the earth was found to be very spongy, consisting of clay and water-bearing gravel. For this reason the excavation was carried about 7 inches below the ties, and the space filled with concrete to a point 1 inch below the grade of the bottom of the ties. The ties were then carefully tamped with a mixture of fine concrete and the space between them filled to the base of the rail, which was also tamped. An additional 2 inches of concrete were then placed as a foundation for the paving.

After a year's service the rails of both tracks were found to be badly corrugated over practically their entire length, the corrugations being from 1 inch to 1½ inches apart and extending from the gauge line over about two-thirds the width of the head. In order to ascertain the cause of this trouble, the paving and the concrete were removed above the ties both in and outside the rails, and a careful inspection was made and measurements taken to ascertain if there were any vertical movement in the road-bed or rails, but none could be detected. It was thus evident that if the writer's theory was correct there must be a lateral bending or vibration of the rail itself, and in order to ascertain if this were a fact an instrument was constructed, as shown in the accompanying illustration. It will be noted that the frame may be rigidly clamped to the base of the rail, and that the vertical arm is provided with a piston *A* carrying a nut *B*, the piston being forced against the head of the rail by a spring behind the nut. A hand or pointer *C* is pivotted at *G*, the upper end of this hand engaging the nut, the other end resting on a graduated arc. The lengths of the upper and lower arms of the hand or pointer are in the ratio of 10 to 1, each graduation representing 1-64 of an inch.

In using this machine it is only necessary to clamp to the base of the rail and set the lower end of the hand at zero, which can be done by turning the piston in the nut. The amount of lateral motion in the head of the rail, due to bending or buckling of the web, will then be indicated by the marker *H*, which is placed against the hand before a car is allowed to run over the rail. In many cases a movement of 3-32 inch was noted.

In order to further verify the results of this experiment, fish plates 30 feet in length were secured and bolted to the outside of the rail, thus giving a support to the head and greatly stiffening the entire rail. After a few months it was found that on rails equipped with these fish plates corrugations were rapidly disappearing. As strengthening the rail in this manner would be too expensive to be practical, it was decided to stiffen the web of the rails by using a special brace on each alternate tie along the outside of the rails. This work was completed a little over a year ago, and a recent inspection shows that nearly all of the corrugations have disappeared.

It has been noted by some roads that corrugations were appearing on rails laid on a concrete base, but in every case that has come to the notice of the writer the rails had been temporarily supported by wooden ties, concrete being tamped under the base of the rail between the ties with no provision made for taking up the shrinkage, which always takes place during the setting and drying of the concrete.

In many cases where track is constructed in this manner the rails seldom have a continuous or uniform support, by reason of their not having anchorages or holding-down devices other than spikes in the ties, spaced at long intervals. This results in a slight movement of the rail on its foundation, and soon causes corrugations to appear, although quite frequently where light rail is used the trouble comes from the

FILING OFF CORRUGATIONS IN A STREET-CAR RAIL

bending or buckling of the web of the rail, as noted above.

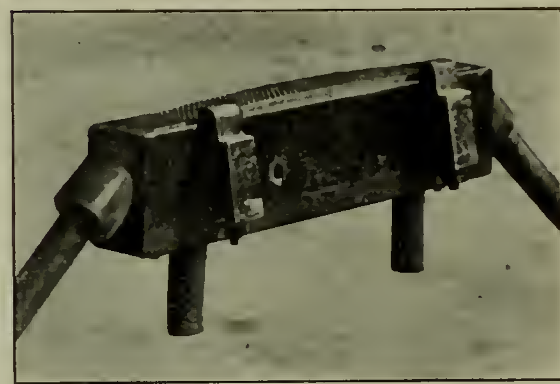
The writer believes that in concrete road-bed construction it is absolutely necessary to provide some means of drawing the rail down on its bed, thereby taking up the shrinkage and preventing any liability of the rail moving on its foundation. In this class of construction vibration can be prevented only by providing a rail of the proper design and an absolutely uniform and continuous support.

When the trouble in tie construction is found to have been caused by loose rails or ties, the only remedy is to grind or file the head of the rails, and to immediately follow this work by firmly securing the rails to the ties and by tamping, using a coarse gravel wherever the foundation is found to consist of soft or spongy material.

Corrugations in light rails, due to the bending of the thin web, are difficult to remedy without considerable expense, but after the heads have been filed to a comparatively smooth surface, it has been found that setting the track to a slightly wide gauge will sometimes prevent a recurrence of the defect.

It is very difficult to grind off the summits of corrugations without a specially constructed machine mounted on a truck, and practically impossible with the usual portable grinding equipment, consisting of an emery wheel connected to a motor by a flexible shaft, because when the eye approaches the rail closely enough to permit the operator to manipulate the wheel, the corrugations apparently disappear.

In nearly all cases filing is probably the best method. The file should be mounted in a heavy cast-iron holder having guiding lugs bearing along the gauge line of the rail and equipped with long handles at each end, so as to permit of operation by two men from a standing position. One form of file holder is shown in the accompanying illlustrations.



A CLOSER VIEW OF THE FILE HOLDER, SHOWING THE FILE AND THE GUIDE LUGS

To prevent the possibility of trouble from bending of the webs of the rails, the writer, about two years ago, had the web of the heavy rail which his company is using increased to a thickness of 9-16 inch. In support of the theory which he has advanced, he would add that on a system of about 600 miles he has been able to reduce the amount of corrugated rail to a very small percentage. The price of immunity from this trouble, however, is eternal vigilance, and, it might also be added, the expenditure of considerable money in maintenance when any form of wooden support is used.

Short-Circuits in Alternators

By E. B. RAYMOND, Electrical Engineer, the General Electric Company

TO properly understand the action of an alternator when short-circuited, the following should be appreciated and understood:

1. The time constant of any circuit and its influence on the rise or fall of current in that circuit—Lenz's law.

2. The armature reaction of an alternator.

3. The self-induction of an alternator.

4. The current in an alternator armature when the latter is short-circuited and the field gradually brought up to normal value.

TIME CONSTANT

The time constant of a circuit is expressed by the formula $\frac{L}{R}$, where L is the coefficient of self-induction and R is the resistance of the circuit. The coefficient of self-induction of a circuit equals (maximum flux passing through that circuit × the number of turns surrounding that flux) divided by (amperes flowing in the circuit × 10^8). The unit of

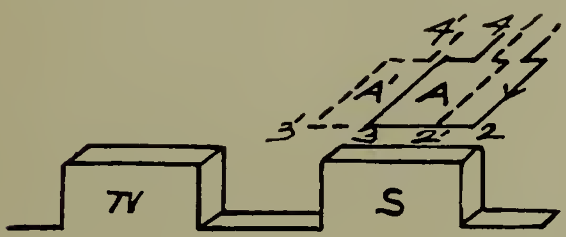


FIG. 1

self-induction is the henry. The self-induction is calculated as shown, which thus gives henrys; when multiplied by $2\pi n$, where n is the frequency, the product gives the inductive resistance in ohms. Thus in any circuit, knowing the flux passing through, the turns, the current producing the flux, and the resistance, the value of $\frac{L}{R}$ can be calculated.

Self-induction in an alternating circuit, or in a circuit in which the current varies, shows itself as a back e. m. f. Thus, if the current in a circuit is growing smaller, the lines of force in that circuit are decreasing. If in any circuit the lines of force are decreasing, there is induced an e. m. f. in such a direction as to produce a current which tends to create lines of force as originally passing through. Thus the current induced by this decrease of lines of force tends to retard the reduction of flux, as well as the reduction of current in that circuit.

This can be seen by referring to Fig. 1. Let the current flow in the circuit *A* in the direction 1-2-3-4 shown by the arrow. The lines of force flow up from the *N* pole and down into the *S* pole. Let the current start to decrease. By this action there is induced a current tending to flow clockwise or in the direction as before. This follows from the well-known law that looking at any circuit along the lines of force, that is, in the direction a free north pole would tend to move, a reduction of the lines of force produces an e. m. f. tending to create current in a clockwise direction. An increase in the lines of force produces opposite results. This, in turn, is, of course, based on the fact that a wire moved to cut lines of force has created in it an e. m. f. in a certain definite direction.

Thus it will be seen that the extra induced current is in the same direction as the original current and tends to keep it from decreasing. Suppose just opposite this circuit there is located another circuit *A'*, short-circuited upon itself. Let us see what occurs when the current in *A* commences to decrease. The lines of force which are created by the current in *A*, and which pass through the circuit *A'*, now start to decrease. As before, this decrease creates an e. m. f. in *A'*, sending the current around clockwise in the direction of 1'-2'-3'-4'.

This current tends to send lines of force in the same direction as the current in *A* (which is now being decreased) originally did. Thus the act of reducing the current in *A* and the flux produced by it has created a current in *A* which tends to hold up this original flux. This has been expressed as Lenz's law, that in all cases of magnetic induction the induced currents have such a direction that their reaction tends to stop the motion which produces them.

It can be shown that this value $\frac{L}{R}$ expresses in seconds approximately two-thirds of the interval which elapses from the time of applying voltage to a circuit to the time when the current has reached its constant value, or $\frac{E}{R}$, E being the applied e. m. f. (a constant) and R the resistance of the circuit. As has been explained, this rise of current cannot be instantaneous, but the back e. m. f. due to the increase must first be overcome, using up a certain definite amount of time.

The formula for this increase of current is $I = I_1 \left[1 - \epsilon^{-\frac{tR}{L}} \right]$

I = current in amperes at any instant t.

I_1 = final current.

ϵ = the base of the Napierian logarithm = 2.71828.

R = resistance of the circuit in ohms.

L = inductance in henrys.

A curve plotted by introducing values in this formula is shown in Fig. 2.

The formula for the fall of current in a circuit closed by the resistance R at the instant the voltage is withdrawn is $I = I_1 \epsilon^{-\frac{R + R_1}{L} t}$

A curve plotted from values obtained by this formula is shown in Fig. 3.

ARMATURE REACTION

In considering the armature reaction of an alternator, let us study Fig. 4, representing an alternator. At the position shown the e. m. f. in the armature is always a maximum. At a position 90 electrical degrees from this the e. m. f. is zero. If the current is in phase with the e. m. f. when the latter is a maximum, the former is also a maximum.

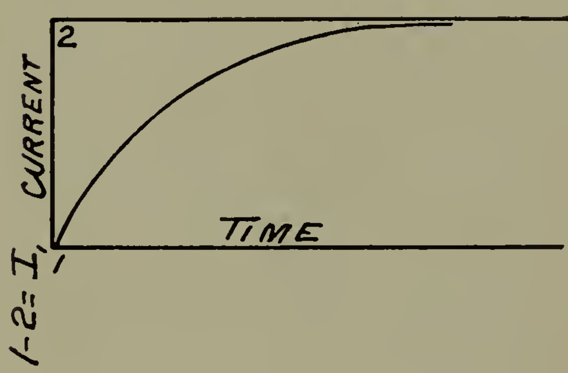


FIG. 2

Since the current in the armature passing through the armature turns creates a magneto-motive force precisely as do the field ampere turns, they must be reckoned with as doing their part in creating the flux through the armature, as well as the field ampere turns. When the current is a maximum, as shown in the position in the figure, the ampere turns of the armature are acting at right angles to the field ampere turns. The tendency is thus to distort the field, the flux growing denser at the pole tips 4 and 3 and weaker at 5 and 6. The effect of this action is to require more field ampere turns, since the extra turns required by the dense tips are more than the less turns required by the weaker tips.

If, however, the current lags behind the e. m. f., it does not reach

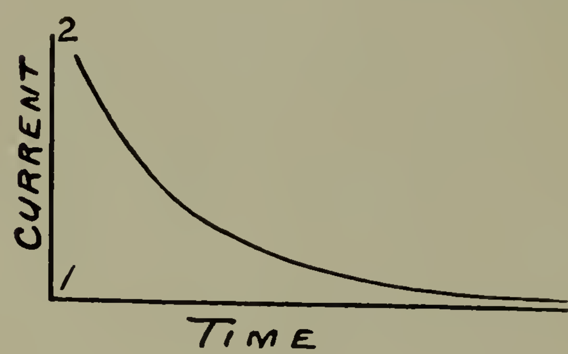


FIG. 3

a maximum until the armature has passed beyond the position shown in Fig. 4. The current may be a maximum at the position shown in Fig. 5. In this case the armature ampere turns exert a demagnetizing effect, as well as a cross magnetizing effect, and hence the extra current in the field coils are required to overcome these. If the current lag 90 degrees, all the turns of the armature oppose those of the field. Thus the voltage of an alternator is the resultant of the ampere turns of the field and the armature, the latter, or lagging, currents tending to pull down the voltage, requiring extra ampere turns in the field to make up.

SELF-INDUCTION

The effect of self-induction in an alternator is entirely different from that of the armature reaction just described. The former is a question of ampere turns of the armature, and their influence on the total ampere turns producing the flux, and hence the e. m. f. The self-induction of an alternator is the back e. m. f. created

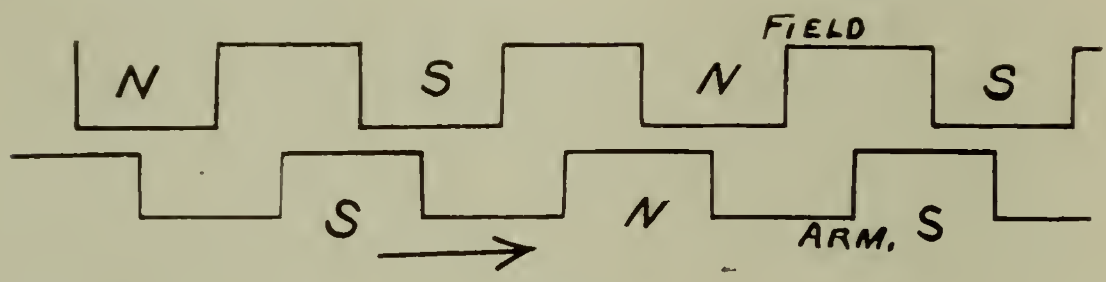


FIG. 4

by the local flux around the wires of the armature proper.

Thus, in Fig. 6 *W* and *W* are two wires in the slot of an armature core which are opposite the pole *N*. From this pole are streaming into the core the lines of force or flux represented by the arrows *a, b, c, d, e, f*. This is the main flux producing the generator e. m. f. and is the flux which results from the field ampere turns and the armature reaction or armature ampere turns described in the foregoing.

There is, however, another flux circulating around the wires *W W*

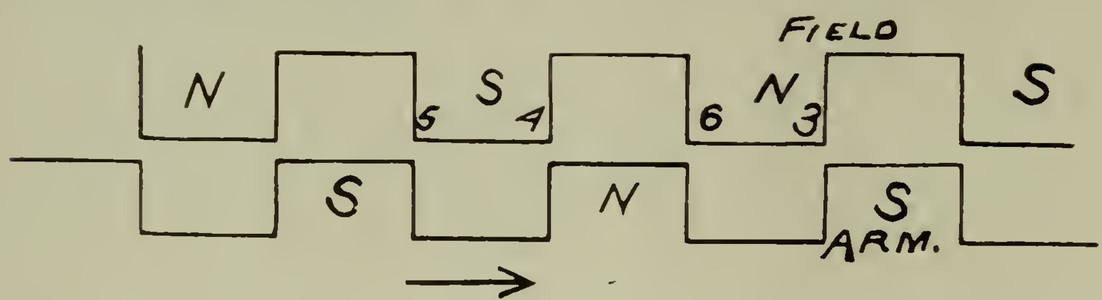


FIG. 5

in the slots, which does not produce an e. m. f. as does the flux *a, b, c, d, e, f*, but holds down the e. m. f. of the machine. The path of this flux is shown by the dotted line 1-2-3-4, circulating around the wires, and is small compared with the main flux of the machine. The time constant $\frac{L'}{R}$ of the flux is far smaller than the time constant $\frac{L}{R}$ of the main flux, for *L* in the one case equals (self-induction flux × armature turns) divided by (amperes × 10^8), and in the other *L'* equals (main flux × turns in spools) divided by (amperes × 10^8).

Let us take a specific case of a 100-KW., single-phase alternator of 20 poles and 500 volts.

Flux per pole = say, 6,000,000 lines.

Turns per spool = 600.

Amperes per spool = 6.

Resistance of 20 spools in series = 12 ohms.

$$\text{Then } \frac{L}{R} = \frac{6{,}000{,}000 \times 20 \times 600}{100{,}000{,}000 \times 6 \times 12} = 10$$

Suppose the armature to have 20 slots per pole and two conductors per slot, and carry a current of 200 amperes. The self-induction flux of this current would be 60,000. The resistance is 0.15 ohm. Then

$$\frac{L'}{R} = \frac{60{,}000 \times 20 \times 2 \times 20}{100{,}000{,}000 \times 200 \times 0.15} = 0.016$$

Thus the time to bring up the main flux after suddenly impressing an e. m. f. on the spools is much greater than the time for the rise of the self-induction flux; or equally, the time for the main flux to die out, the e. m. f. creating it having been removed, is very much greater than the time for the self-induction flux to die out under similar conditions.

SHORT-CIRCUITING THE ALTERNATOR WITH INCREASING FIELD

Let us take a three-phase alternator and without any field current short-circuit all phases of the armature simultaneously. Now gradually bring up the field current. As this is done, the current in the armature will gradually increase until it reaches a value perhaps three times the normal, when the field has reached its normal running full-load value. Of course, at this point there are no armature volts, since the terminals are all connected together, forming a short circuit.

The field current is steady. The armature currents combine to produce a magnetomotive force of constant value (not varying with the wave of current), which is characteristic of a polyphase armature winding, as can be shown. The ampere turns of the field equal approximately those of the armature, the latter currents lagging so as to directly demagnetize the field ampere turns. We thus have a stable condition, as described.

If only one phase be short-circuited, the armature reaction is no longer constant, but pulsating, so that while a stable condition exists, the field current no longer is wholly constant.

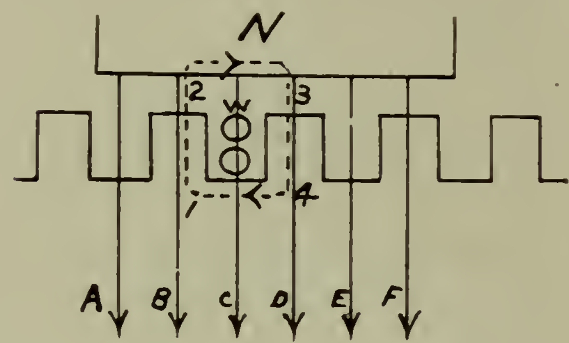


FIG. 6

since the flux resulting from both armature and field ampere turns varies, the field current being constant and the armature pulsating with respect to the field. This flux varying, as described, and passing through the field turns, creates in them an e. m. f. affecting the field current itself. Eddy currents are also created in the pole face, particularly if the pole is not laminated, and tend, according to Lenz's law, to stop the variation.

Let us now apply the above data to the conditions resulting from short-circuiting an alternator suddenly upon itself when running with normal field current. Let us consider first a three-phase alternator which suddenly has all three terminals short-circuited at the terminal board, as if the cable leading from the machine suddenly short-circuited at this point while the machine was fully excited.

The short-circuit may occur at the maximum point of e. m. f. or at some other point. The results are apparently not much different, for what the first e. m. f. wave does not do the next one does. But we will consider for a moment that the short-circuit occurs first at the maximum of the e. m. f. wave of one of the circuits. In that circuit there is a rush of current and an endeavour to fulfill Ohm's law, that is, to reach a current $\frac{E}{R}$ when E equals the e. m. f. at the moment chosen and $R =$ the resistance of the armature (we assume that the external circuit has no impedance).

But this cannot occur immediately. The flux of self-induction must be created as the current rises. The time constant of this self-induction circuit described above must be satisfied. Thus the speed of this rise is such that $\frac{L'}{R}$ of the self-induction circuit will be satisfied. As a matter of fact, the speed is nearly instantaneous, the current jumping to many times the normal value. All this holds true of the other phases of the alternator.

As stated, the armature reaction or magnetizing effect of a polyphase alternator is a constant value, the summation of the armature magneto forces of the various phases always being a constant at any given output of current. Thus the first tendency of this suddenly rising armature current is to act upon the voltage and flux of the machine, since the armature furnishes ampere turns just as important as the field.

Also on a short-circuit, since the inductance of the winding is much greater than the resistance, the phase of the current resulting from this short-circuit is one giving a large lagging effect. Hence this current, as has been shown, is a direct demagnetizing one. Thus this rush of current tends to immediately pull down the flux and the voltage of the alternator to practically zero. While this is accomplished eventually, to be sure, it is not accomplished at once, as will be shown.

Eventually, it is true, this armature current reaches a certain value, the voltage of the armature becoming zero. The flux of the machine becomes practically zero, only enough being left to create an e. m. f. necessary to force the armature current through the armature impedance (a very small amount of flux). The field and armature ampere turns are practically equal and directly opposed.

While all this occurs immediately, as far as the eye can see, as a matter of fact it is done only after the time constant of the main flux is satisfied. For when this armature current jumps up, so also does the field current by an equal amount (expressed in ampere turns).

When the armature current on its first leap has reached its greatest value (perhaps twenty times its eventual constant value), the field current has also leaped to many times its normal value, and, for a moment, the flux is held up by this leap of field current. Thus the $\frac{L}{R}$ of the main field flux comes in and the leap of field and armature current

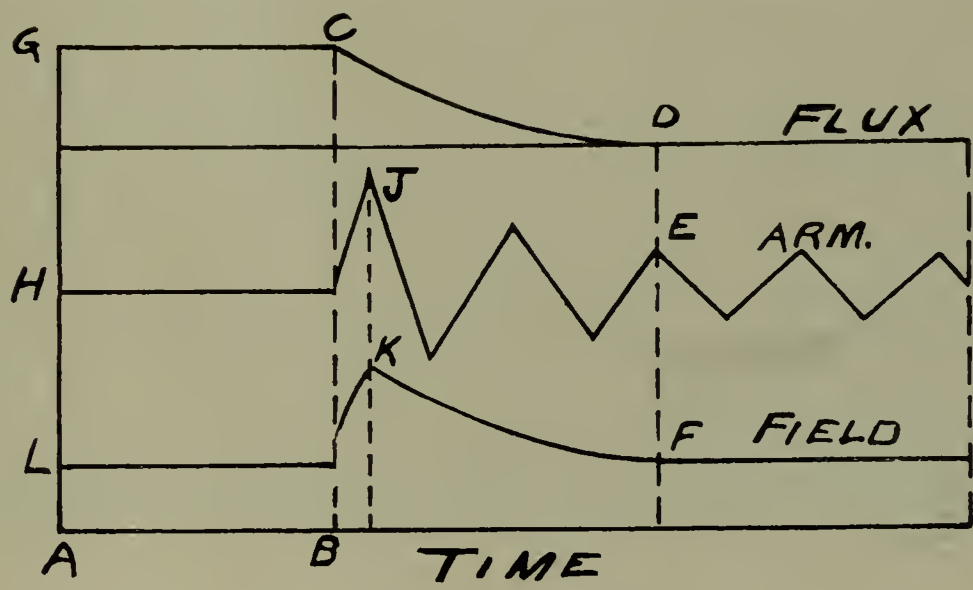


FIG. 7

dies down, in accordance with the curve shown in Fig. 3. The high armature current holds on, creating an enormous current, and only letting go gradually, in accordance with the law expressed by the curve. The flux declines to zero, the leap of the armature current declines to the value described in section 4, and the leap of the field current returns to its old value.

A plot of these conditions might, therefore, look like Fig. 7. The curve *g-c-d* shows the variation of flux, being constant up to the time *a-b*, where the short-circuit occurs, then declining to zero, in accordance with the time-constant law.

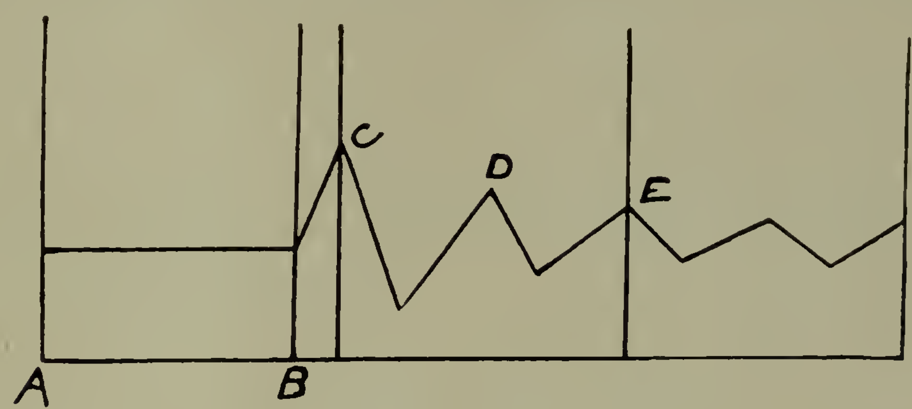


FIG. 8

Curve *h-j-e* shows the armature current, which is zero or any usual running value, up to the time *a-b*, then jumping to *j*, following the time-constant law of the inductance flux (we assume that the field circuit has no inductance, either in the spools or in the external field circuit, as otherwise this inductance should be considered as part of the armature self-inductance in considering the original leap of current) and then declining to the value *e*, which is the short-circuit current with normal field after the rush is over.

Curve *l-k-f* shows the action of the field current. At the time *a-b* of the short-circuit this current leaps up to *k*, holding the flux constant for a moment. It then declines like the rest till normal value is again reached at *f*. If only one phase is short-circuited, all this occurs as before; but now, as has been explained, the field current is no longer a smooth curve. It then might appear as in Fig. 8. The jump occurs at *a-b*, as before, and the tops of the current grow less and less to a final value. An illustration of this from actual readings taken while a short-circuit was occurring on one phase is shown in Fig. 9.

The instrument used was so sensitive and active as to actually plot the wave of e. m. f. or current itself (ordinary commercial instruments simply record the square root of mean square values). An examination of the illustration shows the jump of armature current, the tops of the waves growing less and less. The jump of field current is also shown. The curve is not continued down to the final value, since the switch used to make the short-circuit was automatically opened again, restoring the original condition.

As the figure shows, the field current was running along at 52½ amperes when the short-circuit was applied. The current then jumped to 502 amperes and started to decrease, in accordance with the curve shown in Fig. 3, thus making less and less the tops of the current waves. These current waves of the field were produced mutually by the tremendous alternating "armature reaction" ampere turns (plus the field ampere turns) and the jump and decline of a direct current.

Thus, as is shown, the decline is that of a diminishing direct-current superimposed upon an alternating one, the former being an almost instantaneous jump in a certain direction and then a decline, the latter being due to the field flux variation, and hence a variation of the field current itself (the field current being completed through the exciter armature), resulting from a direct current in the field and a tremendous alternating current in the armature acting together in the same magnetic circuit.

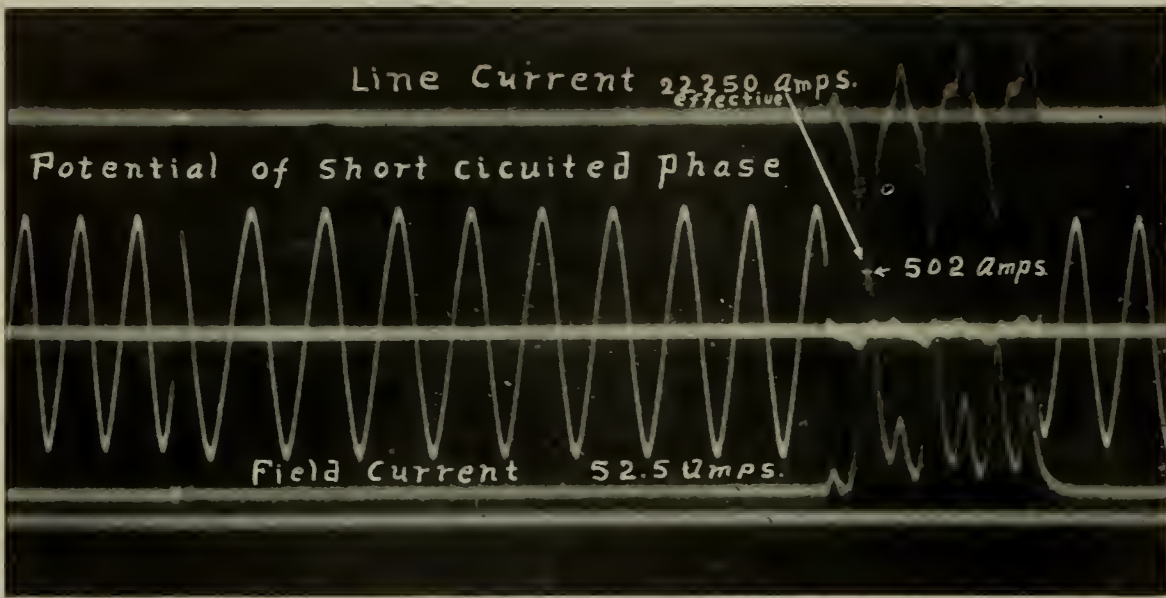


FIG. 9.—AN OSCILLOGRAPH RECORD, SHOWING THE RESULTS OF A SHORT-CIRCUIT IN AN ALTERNATOR

The voltage, as shown in the middle of the figure, goes to zero at the time of the short-circuit (or practically so, the variation being due to the existence of a slight resistance of the cable making the short-circuit), and rises again when it is over. The line current jumps to a very large figure,—22,250 amperes,—and dies down just as described in connection with the field, that is, there is superimposed upon the alternating current a large decreasing direct current, producing the diminishing maximums below the line in the figure which marks the normal line current.

Even during the time of this short-circuit the decrease of these maximums and the approach to an alternating current symmetrical about the line marking the normal line current is very plain in the figure.

During this transient interval with normal flux part of the time and with enormous armature currents the torque or pull on the armature windings is tremendous. The effect upon a machine is as if it had been struck with a thousand hammers.

While a properly designed machine will stand this performance repeatedly without trouble, special precautions in design must be taken to withstand it. The windings which project beyond the core, and which are thus not supported by the slots in the core, unless held firmly by bands inside and out, or unless they are of unusual strength themselves, will be distorted entirely out of shape, thus ruining the winding. In addition, the arms of the revolving element, the keys in the shaft, and the shaft itself all undergo an enormous strain, so that good alternator design means a consideration of mechanical forces far beyond those connected with normal operation. With direct-current apparatus, there is an automatic relief in the fact that the machine will "flash over" at the brushes, relieving the strain to a certain extent.

The Co-operative Electrical Development Association

A Conference of Electrical Interests at New York, December 13

LAST March, it will doubtless be remembered, a conference of representatives from the various electrical interests was held at the Hotel Imperial in New York, to consider plans for the organization of the Co-operative Electrical Development Association.

On Dec. 13, another conference was held at the same place and the subject was again thoroughly discussed. After the meeting was called to order by W. M. McFarland, the following gentlemen responded to the roll call:—

J. S. Anthony, the General Electric Company; F. Bissell, the F. Bissell Company; W. H. Blood, Stone & Webster; W. C. Bryant, the Bryant Electric Company; Walter Cary, the Sawyer-Man Electric Company; J. Robert Crouse, the Co-operative Electrical Development Association; A. L. Doremus, the Crocker-Wheeler Company; W. W. Freeman, the Edison Electric Illuminating Company, of Brooklyn; J. F. Gilchrist, the Chicago Edison Company; E. W. Gilmer, the Warren Electric Specialty Company; R. S. Hale, the Edison Electric Illuminating Company, of Boston; E. E. Jackson, Noble, Jackson & Hubbard; E. S. Kiefer, the Western Electric Company; W. M. McFarland, the Westinghouse Electric & Manufacturing Company; J. E. Montague, the Buffalo & Niagara Falls Electric Light & Power Company; F. J. Newbury, the John A. Roebling's Sons Company; A. D. Page, the General Electric Company; Chas. B. Price, the Pettingell-Andrews Company; F. M. Tait, the Dayton Lighting Company; F. S. Terry, the National Electric Lamp Company; Arthur Williams, the National Electric Light Association; E. W. Goldschmidt, the Wagner Electric Manufacturing Company; E. W. Rockafellow, the Western Electric Company; James R. Strong, the National Electrical Contractors' Association.

The following members were prevented from attending:—

A. T. Clark, the American Circular Loom Company; Henry L. Doherty; W. A. Layman, the Wagner Electric Manufacturing Company; Gerard Swope, the Western Electric Company; O. A. Stranahan, the Allis-Chalmers Company.

Following the roll call, Mr. Crouse told of the work done by the association. His remarks in entirety are given herewith:—

REVIEW OF THE WORK AND THE RESULTS

The purpose of this meeting is to consider the objects and plans and the results of the work of this association, on the basis of which a correct conclusion can be arrived at as to the desirability of putting it in position for continued and more aggressive operation.

During the past few months there has been issued to you a considerable number of bulletins dealing with many aspects of the proposition developed in the past two years, covering the subject in much greater detail and more broadly than the time on this occasion will permit.

The object of our present meeting will doubtless be best served by as brief a review as possible of the proposition, in order that ample time may be allowed for a full and free discussion of it. It will, therefore, be my purpose to cover the more salient points connected with it under the following general headings:

1. Its origin and the more important points of its development.

2. Brief reference to its objects and the theoretical and practical basis.

3. The work which has been done to date.

4. The cost of this work.

5. The results which have been accomplished.

At the afternoon session will be presented the commercial plans formulated for the future, and the constitution and by-laws which have been prepared in tentative form.

ORIGIN AND DEVELOPMENT

The proper perspective, often difficult to find, is essential to a correct estimate of a picture or a proposition in its main essentials and its details. I wish, therefore, to hastily run over, in time and point, its evolution. As to its origin and development, it may be said that the idea was conceived among the incandescent lamp manufacturers in February, 1905.

Their thought, however, was a very restricted one compared with the present plans, inasmuch as they contemplated co-operative activities with the distributing trade which had for their objects solely the increased use of incandescent lamps, doubtless to the disadvantage of any other styles of electrical illuminants, and without particular regard to the power and heating ends of the business. This idea culminated, so far as the incandescent lamp manufacturers were concerned, on May 12, 1905, when an appropriation of $10,000 was made to put the initial plans into effect.

Further consideration of the subject led to the logical conclusion that in any such co-operative movement with the distributing trade it would be a mistake to take it up along such narrow lines, for the reason, in the first place, that there exists a complimentary relation between the lighting end of the business, which is obviously a night load, and the heating and power end of the business, which is obviously a day load. The proper balance of these three elements in electrical service, so as to secure as even a load as possible, is a subject in which all should be interested, as it seems to be the effective means to increase profits, and a possible reduction in rates, which, of course, would mean accelerated business of itself alone.

Not only does this complementary relation exist among the different branches of service of the distributing trade, but likewise a complementary relation exists among the manufacturers in the prosecution of any such plans, for the reason that upon the activity with which the final implements for serving the public with light, heat and power are exploited depends the success of all the manufacturers producing the generating and distributing equipment.

It was, furthermore, obvious that the distributing trade would be very much more logically and quickly interested in co-operative commercial work which addressed itself to their interests as a whole rather than an attempt on the part of one manufacturer, or set of manufacturers, to exploit their product without regard to the interests of others.

This broader scheme for co-operating with the distributing trade was elaborated in a paper presented before the National Electric Light Association at Denver, Col., June 6 to 11, 1905, as a result of which that association was interested enough to appoint a committee of three central station managers to co-operate in the further development of the work.

Broadly on the above basis the subject was again presented before the incandescent lamp manufacturers on February 7, 1906, when it was unanimously endorsed, and an appropriation of one-fifth of one per cent. on their entire sales covering a period of three years was made.

This led up logically to the joint meeting held last March, when the entire proposition was laid before you, and you unanimously passed two resolutions:—First, to the effect that the entire proposition gave good promise of highly profitable returns to all concerned, and that the general plans for its prosecution through the Co-operative Electrical Development Association could be undertaken along equitable and practicable lines.

Second, that a committee be appointed, consisting, for the most part, of yourselves, which was to complete and agree upon a practical form of organization with a view of putting it into effect, and, further, that when, in the opinion of this committee, a sufficient number of organizations and companies had agreed to co-operate in the work, they should be authorized to perfect the organization and supervise its initiatory work.

W. H. Blood, Jr., the president of the National Electric Light Association, as well as the co-operating committee appointed at Denver, evidenced the keenest interest in the development of the association's work, which was getting to be fairly under way in June.

It, therefore, seemed appropriate that the objects, plans and work of the Co-operative Electrical Development Association should be presented to the National Electric Light Association, which was done.

The entire proposition received the unqualified endorsement of the co-operating committee in their report to their convention. President Williams appointed a committee of five central station representatives to co-operate in the further development of the work. Our acknowledgments are due them for their hearty interest, assistance and co-operation.

OBJECTS OF ASSOCIATION STATED

Before describing, briefly, the active work which has been done during the past year, it will doubtless be well to briefly refresh your minds as to the objects of the association as set forth in the constitution:—

First, the promotion of the increased and more extended use of electrical service by the public for light, heat and power against all competitors for like service, as an end in itself, and as a means to the increased demand for electrical apparatus and supplies and the co-operative planning and execution of the various means and methods effective to this end.

Second, the establishment of co-operative relations, both moral and financial, among the different electrical interests from the manufacturer to the consumer, to the end that each may contribute in some measure toward bringing about the above results desired in common by all.

The ground on which the contention is based that limited commercial co-operation is feasible, fair and profitable for the manufacturing, central station and other electrical interests, is the almost absolute dependence of the manufacturer making generating and distributing apparatus and supplies for his market upon the commercial activity of the manufacturer who produces the final utilities through which the market common to all—the public—is in the end electrically served. These utilities are comparatively few in number, as will be observed: in the field of light, the incandescent, the glower, the mercury vapour, the tube and the arc lamp; in the field of heat, miscellaneous appliances for domestic and industrial purposes; and in the field of power, the motor in endless and detailed application.

The money value of these devices is only a fraction of the total volume of the manufactured product, yet they create a demand for all generating and distributing apparatus and supplies, and constitute the edge of the commercial wedge through which is opened up the market for all such apparatus and supplies, — sockets, porcelain, wire, conduits, switches, motors, transformers, dynamos, engines, boilers, and the like.

In their turn, the manufacturers, jobbers and contractors are dependent in varying degrees upon the commercial activity of the central station and others in exploiting electrical service to the public; ultimately we all depend, like links in a chain, upon this great preoccupied, incredulous and indifferent public, with a purchasing power of $18,659,000,000 distributed among its 85,000,000 individual units.

WORK DONE IN 1906.

The work which has been done by the association during the past year may be briefly summarized as follows:

First.—A large amount of literature has been issued by the association in regard to itself, its objects and plans, making a strong appeal to the business sense and business imagination of the entire trade.

The association offered a prize of $1000 for papers on the "Organization and Conduct of a New Business Department for Central Stations," which brought out some of the best thought on the subject. This, in turn, has been made widely effective through publication in all of the electrical trade papers and through dissemination in pamphlet form.

Other commercial literature, such as a complete tabulation of applications of electricity, has been issued, which it is not essential to review in detail at this time.

Second.—Certain advertising agencies were interested in the work for the purpose of affording to central stations and the distributing trade in general the avenue through which could be secured, at reasonable rates, effective advertising and follow-up campaigns for local use.

The work of the advertising agencies, I believe, has been very effective, and large numbers of central stations, and some contractors and jobbers, have taken advantage of their service.

In addition, through the advertising agencies there has been issued to central stations, manufacturers, contractors, jobbers and their salesmen, and the trade in general, a campaign of commercial literature which aimed to emphasize the importance and opportunities for going after the public's business more aggressively.

Third.—The active co-operation of the electrical technical press was early secured, and by the first of this current year all of the papers had opened up commercial departments devoted to the question of ways and means of exploiting most effectively the electrical service. Their work in this field may be summarized briefly.

During 1905, 148 columns devoted to this general subject appeared in the technical press, while during this current year, 1906, 1054 columns were devoted to the subject, which, if capitalized at advertising rates, would amount to $15,700.

I understand that their decision to co-operate with this movement in the opening up of these departments constitutes a departure in general technical press journalism, and must, therefore, indicate their interest in the entire campaign, as well as their disposition to contribute their full share in the work.

Fourth.—A special effort has been made during the past year to interest the salesmen in the work of the association. The logical basis on which the salesmen's interest has been so far secured, and can be increasingly secured in the future, is well put in the following extract from a salesman's letter:—

"Here's wishing the Co-operative Association continued success, as their success is my success."

The attempt has been made to familiarize salesmen with the plans of the association, and in particular to secure their co-operation in presenting, by word of mouth, to the distributing trade the arguments and commercial data, which were sent to them direct through the campaign of commercial literature, trade press, and the like. There can be no question but what this has had a very marked stimulating effect in bringing about results.

Fifth.—The particular point has been made to present the association, its objects and plans before electrical associations of various kinds. It was presented before the National Electric Light Association in June at Atlantic City, the National Electrical Contractors in July, the Electrical Jobbers at Niagara Falls in September, and before six State associations during the summer and fall. In each case it has had an attentive and respectful hearing, and the different associations have shown their interest by the appointment of committees which are to co-operate with the general association. It has furnished in this manner an occasion for the discussion of the commercial phases of the business to a greater extent, I believe, than would have otherwise been the case.

Sixth.—The possibilities of commercial publicity in the newspapers was tested out through the dissemination of an article entitled "The Electric Home," which was very widely used in Sunday editions, and the space devoted to it, capitalized at advertising rates, would have aggregated $10,000 and above.

Along the same lines other electrical articles have been introduced into trade papers of allied industries, of which there are about a thousand, clearly demonstrating that the right kind of matter furnished to them will be freely used.

COST OF WORK

The following is a statement of expenses which have been incurred in the development of this work from May, 1905, to November 30, 1906:—

Traveling and entertaining other than representatives	$5,579.73
Freight, expense and cartage	355.23
Advertising matter	13,470.43

Membership to electrical associations and societies	177.00
Postage	2,099.96
Expenses representatives	397.02
Subscription to electrical trade papers	158.25
Subscriptions to other than electrical trade papers	33.13
Subscriptions to magazines, etc.	43.96
Press Bureau clippings	29.01
Trade paper advertising	440.60
Special newspaper and magazine advertising	200.00
Salaries, officers and clerks	1,496.82
Telegraph and telephone	174.32
Stationery and printing	1,986.46
Sundry expenses	116.47
Office furniture and fixtures	478.31
Prizes	1,000.00
Library	19.71
Total	$28,256.41

The following expenses are either already incurred or contracted for:

Completion of campaign and commercial literature through to February 26, 1906	$3,969.85
Publishing "Applications of Electricity" in Sweet's Index for architects (expense may be incurred 1907)	700.00
Prizes for Electrical Solicitor's Handbook (due for payment 1907)	2,500.00
Advertising and announcing same in trade papers and otherwise	500.00
500 copies of "Looking Forward"	500.00
Fifth central station paper on organization and conduct of a new business department	250.00
Office expenses to January 1, 1907	175.00
Traveling expenses to January 1, 1907	251.71
Miscellaneous bills	133.65
Joint conference, New York	200.00
Total	$9,280.21

The following are the amounts which I would estimate have been been contributed by the activities of those whose co-operation has been secured or induced:—

Trade papers in establishment and maintenance of new business departments	$25,000.00
Advertising agencies in the establishment and maintenance of special electrical departments	25,000.00
Newspaper publicity secured	10,000.00
Total	$50,000.00

On this basis the money energy, therefore, which has been directed to this work amounts to $97,536.62.

GENERAL RESULTS

Broadly speaking, I believe that the general result which has been accomplished is the effective direction of the attention of the entire trade to the consideration of the possibilities of the commercial development of the business, particularly on the part of the distributing trade.

Admittedly, in the words of representative men in the distributing trade, the industry has been essentially technical, and attention has been very largely centered upon the engineering and operative phases of it.

The first commercial note in the National Electric Light Association was sounded in 1903 by Henry L. Doherty, in which he called attention to the above condition, and emphasized the necessity and the possibilities for the commercial and business exploitation of central stations. In 1904 the first paper on advertising and new business-getting was presented by La Rue Vredenburg, of the Boston Edison Company. In 1905 a paper was presented by Percy Ingalls, of the Public Service Corporation, on the same subject; one on signs was presented by O. W. Lee, and the writer presented a paper dealing with this proposition. In 1906 eight papers on commercial subjects were presented by thirteen men, one of these papers being a symposium by six gentlemen.

Perhaps what can be considered an impartial summary of the situation is contained in the report of the committee on progress before the last association meeting by T. Cummerford Martin, which, while I do not propose to read it in full, I wish to insert for your future reference:—

"The year 1905 would appear to mark the beginning of a new period in the development of electric light and power in the United States. It would be difficult to define the nature of the change briefly. Perhaps it is safe to sum it up in the statement that the central stations of the country, realizing the cumulative effect of the reductions in the cost of producing and supplying electricity to the public, had united upon a commercial propaganda to sell the cheaper current thus rendered available. The gaze and the study of the manager were turned outward rather than inward.

"For several years previous a process of consolidation had been going on actively. In most cities the service had become unified, financially and physically, under one management. Elsewhere large sections of individual States had undergone the same centralization of the sources of electrical supply. Beyond this, numerous plants scattered all over the country, ill-constructed, poorly run, badly financed, had become subject to a common ownership or operation in highly competent hands. Thus, while technical changes and improvements did not cease, the interest shifted very manifestly from the engineering to the commercial side of the industry, and at the present moment this newer situation is still developing.

"The central station manager has within the last two years received more advice as to the sale of his current than he endured as to its manufacture in the whole previous twenty. Probably no body of men ever before found themselves the subject from the outside of so much uninvited instruction as to how they should run their own business, and it is natural that they should find themselves bewildered by the multitude of their counsellors. Presently they will discover that no great harm has been done, but that, on the contrary, huge benefit has sprung from this convergence on their field of the experience derived from salesmanship in so many other branches of industry. Lava has ere now proved itself a good fertilizer, and earthquakes afford an excellent excuse for building anew. It may be asserted, without the slightest fear of contradiction, that the industry has been revivified by the publicity campaign of recent date, that it has ceased to minister to the comfort of the many in order to meet the necessities of the million, and that it has made splendid advances toward the accomplishment of its universal purpose and potentialities.

"The manifestations of this new period have been numerous and various, and one of the most encouraging has been the growth of this association. Another has been the activity displayed by the territorial and State associations and the creation of new ones, notably that in New York State. A third evidence has been the interest displayed by the manufacturers in fostering new business, exemplified by the Co-operative Electrical Development Association. Yet a fourth has been the devotion by the technical press of a large share of attention and space to what is, after all, a matter quite without technical or engineering importance, viz., discussions of the art of selling and winning the public eye and ear—in this instance for electrical current and apparatus, though virtually all the arguments and most of the practice would apply to the sale of beer or beef. It is improbable that undue emphasis can be long maintained by all or any one of these agencies, but the present effect of arousing energies that languished is of tremendous benefit; and an outlook that was rather discouraging during 1903-4 was brightened to such an extent that only the best auguries can be formed and entertained as to the future."

As significant of the commercial awakening all along the line, among the largest, as well as among the smaller central stations, H. K. Mohr presented a paper before the Edison Association of Illuminating Companies at their last meeting on the subject of "Costs and Results of Soliciting and Advertising," a number of points from which I am tempted to extract. The following paragraph will, however, answer the purpose:—

"From the inception of the electrical industry special care and attention have been given to the keeping up of accurate engineering data and records in a more or less uniform manner.

"Is it not time, then, for us to begin keeping uniform records pertaining to the business-getting department, so that questions regarding important commercial problems could be asked and answered readily and with certainty?

"Would not a committee, whose duty it would be to collect the data available and submit the results obtained and conclusions reached in the shape of a yearly report to the various member-companies, be of the greatest practical value and assistance to us all?

"This association has at present six active committees, exclusive of the executive committee, and of this number there is only one, the committee on electrical heating, which is directly concerned with the commercial side of the business. If it is true that the gaze of the central station manager has 'turned outward,' and the interest shifted from engineering to commercial problems, may we not hope for a committee to help us overcome our rapidly increasing difficulties?"

The programmes of the different State associations have been noticeable, this year, for the notice taken of papers presented on the subject of "New Business-Getting." In addition, the technical press, both in its editorial comments and in its new business departments, reflects the vastly increasing attention being, given to this sbuejct.

CONCRETE RESULTS

During the past two months an effort has been made to get together the concrete results which appear to have followed this entire campaign. These naturally pertain to the results in the central station field, inasmuch as well-organized work has not been undertaken and has not been possible in the other fields by reason of the insufficiency of funds, as well as on account of the time necessary to prepare such campaigns.

This result is herewith presented for your attention in the form of a detailed report, classified by states.

On the average it costs central stations 45 cents per 16-candle-power equivalent of new business secured through advertising, soliciting, etc.; 30 cents for soliciting expense, and 15 cents for advertising expense.

Using these figures as the unit, the $551,167.50 noted at the bottom could reasonably be expected to result in a total added business of 2,720,050 16-candle-power equivalent.

Thirteen 16-candle-power equivalent to the horse-power would aggregate 209,234 horse-power.

This, at $100 per horse-power, would amount to $20,923,400 for the necessary generating and distributing apparatus.

This assumes that all business was added to the peak load, which would not be the case.

The result should, therefore, be discounted, but to what extent is difficult to determine.

This statement covers reports which have been received directly or through

STATE.	Total Number Plants Reporting.	New Business Departments Organized. 1906.	New Business Departments Organized. Previous.	Number of Plants Adding Solicitors this Year.	Number of Solicitors Added this Year.	Begun Direct Advertising this Year.	Begun Direct Advertising Previous to this Year.	Begun Newspaper Advertising this Year.	Begun Newspaper Advertising Previous to this Year.	Increased Advertising Appropriation this Year.	Amount of Increase. No. Plants Stating Increase in Dollars.	Amount of Increase. Amount.	Amount of Increase. No. Plants Stating Increase in Per Cent.	Amount of Increase. Increase in Per Cent.	Number of Plants Not Stating Amount Increase.	Opened up Display Room this Year.	Opened up Display Room Previous to this Year.	Operating their own Electric Sign this Year.	Operating their own Electric Sign Previous to this Year.
Alabama	12	1	2	3	4	2	1	3	0	3	2	$1,800	1	100	0	2	1	4	0
Arizona	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arkansas	15	0	2	2	6	3	1	4	0	5	1	500	1	300	3	2	2	2	0
California	30	4	1	11	21	8	1	10	1	9	1	180	1	100	7	7	1	9	1
Colorado	17	1	3	5	7	4	2	7	2	4	0	0	0	0	4	5	1	5	1
Connecticut	8	0	0	0	0	2	1	3	1	0	0	0	0	0	0	2	1	3	0
Delaware	3	0	1	2	3	1	1	2	0	2	1	50	0	0	1	0	1	1	0
Florida	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Georgia	17	1	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1	0
Idaho	8	2	0	2	3	2	0	3	1	3	1	1,000	1	100	2	2	2	4	0
Illinois	102	7	6	10	20	14	2	18	3	15	3	3,100	3	615	9	6	4	7	0
Indiana	41	5	4	7	11	9	0	10	0	8	2	700	3	75	0	10	0	9	0
Indian Territory	1	1	0	1	1	1	0	1	0	1	0	0	0	0	1	1	0	1	0
Iowa	48	6	6	12	12	13	0	15	1	13	3	1,800	1	25	9	14	1	13	0
Kansas	22	2	2	4	5	6	0	11	0	10	3	680	3	275	4	9	0	5	0
Kentucky	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Louisiana	6	1	0	1	3	1	0	1	0	2	0	0	0	0	2	1	0	0	0
Maine	12	2	1	2	7	3	0	3	0	3	0	0	1	200	2	2	4	4	1
Maryland	5	1	0	1	1	1	0	2	0	1	0	0	0	0	1	0	0	0	0
Massachusetts	30	6	2	8	13	6	1	9	3	8	2	1,200	3	150	3	4	4	8	0
Michigan	53	7	2	10	25	10	0	14	0	11	3	2,760	0	0	8	10	2	10	1
Minnesota	29	3	2	5	8	7	1	9	3	9	1	500	3	70	5	7	1	4	1
Mississippi	10	1	0	2	2	0	0	2	0	1	0	0	0	0	1	2	0	1	0
Missouri	35	2	0	4	13	6	0	3	0	6	1	1,500	1	50	4	7	0	4	0
Montana	7	3	0	2	2	1	1	2	2	1	1	1,000	0	0	0	1	1	3	0
Nebraska	22	0	2	2	3	4	0	2	0	3	2	1,200	0	0	1	3	1	0	0
Nevada	2	1	0	1	1	1	0	1	0	1	0	0	0	0	1	0	0	1	0
New Hampshire	11	2	1	2	2	3	0	3	0	2	1	150	0	0	2	3	0	2	0
New Jersey	6	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0
New York	55	8	7	17	61	15	1	15	4	15	3	4,000	2	125	9	12	1	16	1
North Carolina	11	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
North Dakota	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0
Ohio	90	4	3	13	24	17	0	18	1	12	4	14,100	1	100	7	16	2	17	0
Oklahoma	10	1	2	2	3	4	0	3	0	3	1	1,000	0	0	3	3	0	4	0
Oregon	6	2	0	2	3	2	0	1	0	2	0	0	0	0	2	3	0	2	0
Pennsylvania	47	5	1	10	31	7	0	16	0	6	0	0	1	100	5	10	1	9	0
Rhode Island	2	0	1	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0
South Carolina	6	1	0	1	1	0	0	2	1	1	0	0	0	0	1	1	1	1	0
South Dakota	9	0	0	1	1	0	0	0	0	1	0	0	0	0	1	3	0	0	0
Tennessee	13	1	0	2	6	5	0	3	0	3	0	0	3	150	0	11	1	2	0
Texas	38	7	2	11	15	17	1	19	0	17	2	110	4	100	11	11	0	11	0
Utah	6	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0
Vermont	12	1	0	1	1	2	0	2	1	1	0	0	0	0	1	2	1	1	0
Virginia	6	1	0	2	4	3	0	2	0	3	1	1,500	0	0	2	1	1	1	1
Washington	10	1	0	1	1	4	0	4	0	3	2	320	0	0	1	4	0	5	0
West Virginia	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wisconsin	29	3	3	2	6	5	1	6	2	6	2	3,100	0	0	4	4	2	6	1
Wyoming	4	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Total	934	96	58	165	331	193	17	232	29	195	43	42,250	33	.....	119	165	38	181	8

193 Central stations direct-by-mail advertising	$218,447.50
232 Central stations newspaper advertising (estimated $200.00 each)	46,400.00
96 Managers of new business departments at $1,500.00 each	48,000.00
331 Solicitors at $720.00 each	238,320.00
Grand total	$551,167.50

NOTE.—165 display rooms opened by central stations not taken into account.

salesmen from 934 central stations. It shows that 96 central stations organized new business departments this year and 58 previous to this year; that 165 central stations added solicitors this year, amounting in the aggregate to 331 solicitors; that 193 began direct advertising this year, and 17 previous to this year; that 232 began newspaper advertising this year, and 29 previous to this year; that 195 increased their advertising appropriation this year, 43 of them making the direct report that they had increased their advertising appropriation $42,250; 165 central stations opened up display rooms this year, 38 having opened them up previous to this year; 181 began operation of their own electric sign this year, and 8 previous to this year.

This result has been capitalized, as you will note, and it would appear that on the basis of a fair estimate $551,167.50 has been spent in going after new business by the stations indicated and others indicated from other sources.

On the basis of the average expense for securing new business, this amount should have resulted in new business to the amount of 2,720,050 16-candle-power equivalents, which, figured on the basis of $100 per horse-power, would amount to $20,923,400 for the necessary generating and distributing apparatus. Certain qualifications are suggested in this connection in the table, where figures are given in detail.

Four gentlemen, who are in position to know, inform me that, in their opinion, the very rapid increase in the demand for incandescent lamps is traceable in some considerable degree to the work of the association and those co-operating with it. I understand in a general way that, without having exact figures, the gain in the incandescent lamp business this year has been 25 per cent. over 1905, as contrasted with a gain of 8 per cent. in 1905 over 1904, and of 5 per cent. in 1904 over 1903.

Representatives of the manufacturers of heating devices have stated openly before State conventions their belief that the association has contributed very largely to an increase in this new branch of the business beyond anything which was reasonably expected on the basis of its previous growth.

As to the results which may have been brought about in other styles of illuminants and in motor work, I have no means of knowing very definitely, except that as the work has been addressed to all branches of electrical service impartially, similar results should have been secured.

I believe that while remarkably good results have been accomplished, yet they are to be qualified in terms of the general prosperity prevailing in all lines of business. Undoubtedly an unusual increase would have been enjoyed by the electrical business, regardless of the association and its work.

Individual judgment will vary on this, but the following figures will be found interesting and suggestive:—

	Business Resulting.	Expense of Association.	Association's Expenses Per Cent. of Business.,
Business resulting as figured	$20,000,000	$30,000	.0015
One-half business resulting as figured	10,000,000	30,000	.003
One-quarter business resulting as figured	5,000,000	30,000	.006
One-eighth business resulting as figured	2,500,000	30,000	.012

As an offset against too great a discount of the result, the fact should be borne in mind that it has not been possible to secure complete returns on the results. The writer has personal knowledge of a number of such cases where the details are not available for use.

Most any way you analyze these results, I think you will be forced to the conclusion that this plan of co-operative commercialism,—the massing of a small fraction of our combined selling forces on the public's business,—opens up an avenue for increasing the sale of electric current, apparatus and supplies which is very highly efficient.

If you should credit the association and those co-operating with it with the fourth result above mentioned, it would more than have justified the original appropriation of $287,000 suggested in Denver in 1905, assuming a profit to the manufacturers of 15 per cent. on the increased business.

In conclusion, permit me to express my very great appreciation of the uniform courtesy, patience and co-operation which has been given to me in my personal relations with you all in the development of this work thus far. Whether or not it is written in the book that our joint fortunes will lead us to the actual initiation of the association and the further prosecution of its work, we may all, I believe, feel some personal satisfaction in having made an honest and an earnest effort to evolve a commercial plan, which, while justifying itself in the cold dollar fashion of business, gave at the same time promise of improving both personal and trade relations in the future.

The incandescent lamp manufacturers are the generous fathers of this proposition, which Mr. Jackson, at your meeting last March, was pleased to call my "baby." Carrying out the simile, I feel that it has now outgrown its swaddling clothes, has cut its eye-teeth, finds a milk diet, in consequence, inadequate to its further development, has quite broken loose from its maternal apron strings, and appears before you as a very promising commercial youngster, whose future growth and development must be entrusted to the larger interests and guidance of the whole electric family.

In the discussion following the reading of Mr. Crouse's paper, it was asked if the light, power and incandescent lamp manufacturers would unite to carry out the plan suggested. Mr. Crouse, replying, said that the resolution appropriating one-fifth of 1 per cent. was to become operative as from the first of the year. The original $10,000 was spent and also $20,000 advanced by the incandescent lamp manufacturers. They had thus discharged their share for three years, that is, one-fifth of 1 per cent. on their sales, which for one year would be easily $10,000.

A representative of the incandescent lamp interests said that many inquiries which they had received could be traced to Mr. Crouse's work, and that they could praise his work fully. The proportion which they would be called upon to pay would be very much less than the benefits received. They were, therefore, perfectly contented with contributing their share and could heartily endorse what had been done.

In commenting on the increase in business since the inauguration of the association, it was said that this progress was as good a barometer as could be obtained. The total increase in the incandescent lamp business would not be less than 20 per cent. The total of all manufacturers (quoting from figures of the past sixteen years) was less than the figures of last year. The percentage stated was the greatest increase in that period, and shows that nearly all central stations cover their business by careful advertising and soliciting.

From a selfish standpoint, the next question would be whether the business men might not say that they are fairly started and adopt these methods without the expense of the association, or whether the association can get every station in the country to adopt this method and aid the association in what they had to consider. The work, considering what has been done toward the success which the stations are having, by the use of certain methods in keeping before the central stations the advanced methods of getting business, was worth the expense.

An incandescent lamp representative thought a portion of the success arose from the embarrassment of the original committee that was appointed by the lamp manufacturers to take up the scheme. Mr. Crouse, as chairman of the committee, called upon various advertising agencies for the purpose of acquainting them with the plans. He then called a meeting of the committee and invited the advertising agencies to attend. Each one was given a separate hearing, but in the end all the propositions looked so good that the choice of one could not be made. The question then was how to put them all to work.

In discussing the length of time it would take to make the work effective, none of the advertising men place it at less than a year, and some more, up to three years. In regard to supplying orders, business is in the same condition. To bring out things in a year or a year and a half from now, the pressure should not be taken off. It would provide a wedge for business in the future, and whether we are confronted later on with the embarrassment of unfilled orders, it will not work to the disadvantage of any.

A representative of the central stations stated that they are agreed that the association's work is helping them tremendously. Salesmen coming into his office had commented very favourably on the pamphlets sent out by the association. Other companies were feeling its effects. In Batavia things had been at a standstill for many years, but it is now one of the liveliest towns in Western New York. He had spoken to nearly all the central station managers in his section of the country, and they had said that the association had been a help to them.

Another incandescent lamp representative agreed that the present was no time to rest, but that, on the contrary, they should push ahead harder than ever. It would take some time to work it out in the proper way, and he thought they would find that in a year, or two years, or three years, the business now being handled and the orders taken in would not be as great as to-day. Instead of letting go, therefore, they should push hard.

A representative of the jobbers said that their observations had confirmed their belief in the work. He thought that the jobber was furthering the work, and had yet to find the men who were not interested. He had watched the movement very carefully and had been impressed by the awakening of men in business in the smaller towns, where the people were who should be awakened and where they would make large sales.

He had been told recently by a man who had gone to the bottom of the matter, that the men in the business were themselves doing all this work; but he himself did not believe that. He believed that there were thousands of men who were not as thoroughly alive as they might be.

According to figures submitted, said another speaker, 85 per cent. of the central stations are located in comparatively small cities. In a great proportion of these towns the central station manager had some other business and he gives his surplus time to the central station affairs. One man, in a town of 30,000 people, had profited by the association's work, and had acknowledged that he had been making a mistake for the last ten years. Now he is up to date and he is busy. They now have display signs, have advocated electricity for illuminating, heating, and the like. The speaker admitted that the central station man was doing his work, but it was with the ammunition furnished him by the association. He did not expect the association to aid in the work of the large stations, but expected it to reach the small stations, as it had been doing.

Not only the small companies, but the larger ones as well, said a central station man, had been helped by the association's work. He could, however, understand the manufacturers' feeling that possibly it might not be wise to put on too much pressure just now. His company, however, would continue to push as hard as possible. From the central station standpoint, the sooner the matter is taken up, the broader the scope of the plan, the more effectually carried out, the better it will please the central stations. He believed that the consumer could be reached by newspaper and magazine advertising.

It was also stated that the central stations which were already doing a good deal had been encouraged to do more, and central station managers were in very much better condition now than anybody else in the country, and they are feeling and realize that they must be up and doing. The central stations should be included in this movement. They are going to be great factors, probably greater than the manufacturers. He thought that a magazine campaign would be productive of the best results, as they are widely read by the people who can afford to use and pay for electrical conveniences.

One of the questions at the beginning, said W. M. McFarland, was as to whether the manufacturers and the central stations would go hand in hand. They had to contribute on account of the benefit to them. He thought the latest speaker's statement would strengthen the hands of the representatives of the manufacturing companies and strengthen the appeal of this association to them.

It was said that in small towns the manufacturers were changing over to electric power, and that particular line would be worth more to his company than the amount which they planned to contribute if the proposed organization went through. When a man moves to one city from another where electricity has been pushed, he is far more apt to become a user of electricity than he is if he comes from a city where it has not been pushed. In the long run, it is well worth while to have it pushed in other cities. The magazine advertising will be even more than valuable.

Another central station representative said that while at first the plan did not impress his company very much, they soon discovered that there seemed to be no limit to the field to be developed by the proper management of the company. They were very enthusiastic. Central stations have learned that this developing scheme is the proper way to take hold, and advertising is the question of the hour. He had learned from central station men all over the country that they are taking a great interest in this work, and this interest is growing constantly, which will mean that the central station, regardless of its size, will endeavour to push for more business, which means more apparatus, more lamps, and more business for everybody concerned; it should be pushed along. As a representative of a medium-sized station, he would say that they would be glad to assume their proportionate part of the expense.

The art of making lamps, said another speaker, was not wide open until 1894, and the following seven or eight years showed that the business was doubling about every seven years. From 1903 to 1905, the business did not increase perceptibly. Something evidently had to be done. More people were making lamps. The old manufacturers were being crowded and doing less business; whereupon, the lamp manufacturers inaugurated this scheme. They had proved, and had the right to claim, that they had brought about the prosperity of the apparatus manufacturers, due to advertising their cause. For their own means and business they had made larger contributions and had brought about the necessity for the apparatus manufacturers to increase their plants.

The various bulletins and information which had come to his company from time to time, said one speaker, had been sent out to the branch offices and selling men, and had proved of considerable help to them. He felt that the work of development should be carried on in one way or another, and that undoubtedly the work of the association had had a good deal to do with the general business acquired by the manufacturers. He felt that as soon as the plans were definitely laid out and submitted to the officials and directors of his company they would be willing to co-operate.

Mr. Crouse then outlined the plans for the future of the association.

CO-OPERATIVE COMMERCIAL PLANS FOR THE FUTURE

Membership in this association is planned on the basis of three years, as will be later observed in the constitution and by-laws. It may be well, therefore, to sketch the line of activity which it might be planned to reach in 1909, or the third year of its operation.

While this programme is undoubtedly more elaborate, extensive and expensive than we are any of us prepared for to-day, and while in the light of further experience it may be very materially changed, a glance ahead may serve the purpose of indicating the possibilities for continued development.

The officers and their assistants will be as follows:—

President, having general supervision of the association's work.

First vice-president, having general charge of the work in the electrical field, co-operating with the larger central stations (100,000 population and above), syndicates, jobbers, contractors, and with the trade press and advertising agencies.

Second vice-president, co-operating with moderate sized central stations, jobbers, contractors (cities of a population of 10,000 to 100,000), trade press and advertising agencies.

Three representatives, having the same line of work as referred to in connection with the second vice-president (cities of 10,000 to 100,000).

Twelve representatives, having the same line of work as immediately above described, but for cities of 10,000 population and under.

One mechanical and electric engineer, to advise on alterations and equipment where essential to further commercial progress.

A corps of expert solicitors, one for light, one for power, and one for heat.

One representative, co-operating with the electrical contractors and their trade press.

One representative, co-operating with architects, builders, real estate dealers, contractors, their trade press, associations and conventions, State and National, emphasizing the very great present and prospective utility of electric service for light, heat and power.

Secretary-treasurer.

One reader, reviewing all literature from which could be extracted useful matter for electrical publicity through any channels.

Three stenographers.

Two clerks and one office boy.

Monthly issues to central stations of commercial data and information stimulating and instructive in character, similar to that issued during 1906. The character of this literature to be adapted to cities of 10,000 and under, 10,000 to 100,000 and 100,000 and over.

Monthly issues to electrical contractors of commercial data and information which would be instructive and stimulating in character suited to their trade conditions.

Bi-monthly issues of commercial data and literature to architects (5000), builders and contractors (5000), their trade press, associations, etc., emphasizing the very great present and prospective utility of electric service for light, heat and power.

The "Electrical Co-operator," as the official organ of the association, issued quarterly to a list of 16,000 central stations, manufacturers, jobbers, contractors, their salesmen, electrical associations, the trade press, etc., in which the activities of the association along all lines will be reviewed.

Publication of the "Applications of Electricity," as now compiled by lines of business in Sweet's Index of Construction Material, reaching 5000 architects.

Special advertising in trade press of the building and contracting trades.

Special work by the electrical technical press, the issuance of special commercial supplements, etc.

Prizes similar to ones already offered and advertised for electrical solicitors' hand-book.

Establishment of a school for electrical solicitors.

A national commercial press bureau for the dissemination of news of every character pertaining to electrical service and development to the daily press of the country.

A national campaign of advertising in magazines and periodicals.

PLANS FOR 1907

The plans proposed for 1907 would consist of such of the above general plans as are indicated as follows:—

President, having general supervision of the association.

First vice-president, whose general duties would be as previously noted in the first sketch.

Second vice-president, whose duties would be as indicated in the first outline.

One representative, whose duties would be as previously noted.

A corps of expert solicitors, one for light, one for power, and one for heat.

One representative, co-operating with the electrical contractors and their trade press, as noted above.

One representative, co-operating with architects, builders, etc., as noted above.

Secretary-treasurer.

Reader, as noted above.

Two stenographers, as noted above.

One clerk, one office boy.

Monthly issues of commercial literature to central stations, as noted above.

Monthly issues of commercial literature to electrical contractors, as noted above.

Bi-monthly issues of commercial literature and data to architects, builders, contractors, etc., as noted above.

The "Electrical Co-operator," quarterly publication, official organ of the association, as noted above.

Publication of the "Applications of Electric Current" to architects, as noted above.

Special work by the electrical trade press, as noted above.

Prizes offered and advertised for electrical solicitors' hand-book.

A national commercial press bureau, as noted above.

A national advertising campaign in magazines and periodicals.

LINES OF WORK ELABORATED

It will not be possible within the reasonable limits of time at our disposal to go into complete details as to the specific lines of work which are planned under the above headings, as a number of them could be elaborated into a paper by itself.

However, enough may be suggested under each heading to indicate its directness and practicability.

THE PRESIDENT'S WORK

The president's work, as is obvious, will be along the line of the general supervision of the activities of the association, presenting the association and its work before National and State associations of the central stations, jobbers and contractors, as well as before the associations of manufacturers, aiming to increase the interest in the work and to stimulate greater co-operation in making its work increasingly effective. His time would also be devoted to a considerable extent in increasing the membership of the association.

THE FIRST VICE-PRESIDENT'S WORK

The first vice-president would have immediate supervision of the detail work in the electrical field, spending the greater portion of his time calling upon the lighting companies, jobbers and contractors in cities of 100,000 and over for the double purpose of giving and receiving information about the latest and most effective selling means and methods. He should be able to profitably address the soliciting forces of the companies and to stir up increased enthusiasm and interest among them by reviewing the work of other companies and soliciting forces where the most progressive methods are followed and the best results secured.

If the suggestion already made is found to be practicable, he could arrange for the interchange of expert solicitors from one company to another, which would doubtless be found to have a very stimulating effect upon the soliciting forces, and experience would undoubtedly suggest other lines of activity along comparable lines which could be followed out.

Where conditions would indicate the advisability, he would arrange to give a dinner to the leading commercial men connected with the central station, jobbing and contracting interests, at which the association work could be presented under most favourable circumstances. Much good to the business would doubtless result from such all-around interchanges of ideas, experiences and improvement of acquaintances.

Such general subjects as co-operative advertising of electrical service in the local newspapers by all interests affected could be discussed, which seems to offer great possibilities in the few instances in which it has been tried.

He would use his good offices to further the interests of the co-operating advertising agencies where he believed their service would benefit the local interests.

He would make a point of furnishing the trade press with such commercial information as he secured in his work as would be stimulating to other companies, for use in their new-business departments.

Finally, it would be his duty to turn in for permanent record a report on the general situation in each city and a statement in detail as to the commercial conditions existing, so that in the course of time the progress made, as reflected by increased commercial activity, could be tangibly gotten at.

SECOND VICE-PRESIDENT'S WORK

The work of the second vice-president would consist of substantially the same lines of activity, except that it would be devoted to cities of a population of from 10,000 to 100,000.

He could, in addition, make a point of urging upon such of the central stations as are not represented in State and National associations the importance of membership and the advantages to be gained from it.

SPECIAL REPRESENTATIVE'S WORK

The special representative, as here provided, would work along the same general lines, except that his work would be among cities of a population of 10,000 and under. Some special conditions are, however, met with in these cities which are not met with in others, namely, the question of the establishment of day circuits, and the existence of the old flat-rate system of charging for service.

Referring to the question of day service in these cities, which is an important one, it will be noted from the table below that 67.78 per cent. of the central stations in Michigan and 65.6 per cent. of the central stations in Ohio do not maintain 24-hour service.

This condition prevails, as already noted, largely in cities of 15,000 population and below. The president of the Michigan Electric Light Association, at their last meeting, stated that many of such stations should be operating a 24-hour service, that there existed no sufficient reason why they should not. This offers, therefore, a very fertile field for effective work.

The detailed statistics in reference to this situation in the States of Michigan and Ohio, cited as being typical, are noted below:—

As regards the system of flat-rate charging, this, of course, affects the question of day circuit, and its deficiency as a general system of charging and extending electric service is well known.

WORK OF EXPERT SOLICITORS

Provision is made for a corps of expert solicitors, one for power, one for heat, and one for light. Under the direction of the first vice-president, they would be employed in assisting such central stations as may be found to desire it in starting an active soliciting campaign. In this connection it has already been suggested by several of the smaller central stations that they would welcome an arrangement whereby they could secure the services of a solicitor for a part of his time. This suggests a line of work which, if found practicable, might be indefinitely extended. It could also probably be placed upon a self-sustaining basis after some experience has been gained in the work.

REPRESENTATIVE AMONG ELECTRICAL CONTRACTORS

Provision is made for a representative who would devote his attention to the electrical contracting interests, co-operating with them along lines which might reasonably be expected to result in increased business. This work would be based upon an analysis of the commercial practices of the most progressive contractors, with the object of calling such methods as forcibly as possible to the attention of contractors generally.

CENTRAL STATIONS GIVING NIGHT SERVICE ONLY, AND NIGHT AND DAY SERVICE.

State.	Total Number.	Per Cent. of All.	Night Service. No.	Night Service. %	All Day Service. No.	All Day Service. %
	5,000 and under.					
Michigan	192	80.34	153	79.69	39	20.31
Ohio	181	67.54	162	89.50	19	10.50
	5,000 to 10,000.					
Michigan	19	7.95	6	31.58	13	68.42
Ohio	46	17.16	12	26.09	34	73.91
	10,000 to 100,000.					
Michigan	23	9.62	3	13.04	20	86.96
Ohio	31	11.57	1	3.23	30	96.77
	100,000 and over.					
Michigan	5	2.09	0	0.	5	100.00
Ohio	10	3.73	1	10.00	9	90.00
	All sizes.					
Michigan	239	0.	162	67.78	77	32.22
Ohio	268	0.	176	65.67	92	34.73

He would also examine the conditions under which central stations and contractors are at present working together to the best advantage, with the object of making the basis of such relations known widely in both the central station and contracting fields.

For the purpose of creating as much interest as possible in the association and its commercial work, the officers of the National Electrical Contractors' Association have offered the use of their trade paper for the establishment of a new-business department along the same general lines as those already in vogue in the technical press, but naturally conformable to the special requirements of the contractors.

REPRESENTATIVE FOR WORK AMONG ARCHITECTS, BUILDERS, CONTRACTORS, ETC.

Provision is made for a representative whose work would consist of a broad and general study of the proposition of the wiring of property of all kinds, both old and new. He would make careful examination into the relations existing between architects, builders, contractors, real estate dealers and the electrical interests. He would make it a point of getting in touch with the National, State and city associations of the architects, builders and contractors, with the object of presenting before them papers dealing with the subject, and emphasizing the very great present and prospective utility of electric service for light, heat and power.

This would involve a strong recommendation of the policy of freely specifying extra outlets—floors, baseboards and walls—as well as separate circuits for heating and miscellaneous electrical appliances, which is now not so generally done as would be in the interests of both the owner or occupant, and the electrical interests, which would directly profit.

He would prepare, at the same time, articles for the trade press of these different trades which would keep this subject before them in a live and instructive manner.

He would tabulate all the effective means and methods as now employed by central stations, contractors or others to secure the wiring of old and new construction work, and put this into the most effective and convenient shape for general distribution through the trade press and special campaign of literature reaching these trades, as will be later referred to.

As he would be in touch with the latest practice in wiring and application of electrical devices, he would take charge of keeping the lists of applications of electric current up to date and issue them to the electrical trades and to the architects and contractors.

His work would put him in position to report to the press bureau any interesting or novel applications of electric service which would be written up and sent to the trade papers reaching the trade which would be interested.

COMMERCIAL LITERATURE ISSUED TO CENTRAL STATIONS

During the past year a campaign of commercial literature has been issued to the central stations and the jobbing, contracting and manufacturing trade in general, which has emphasized aggressive commercialism along the general lines of service, soliciting and advertising. This campaign was keyed upon the practice of the most progressive and successful central stations, and its principal argument was based upon the general proposition that if $6 and $8 per capita income for electric service is proved in numerous instances to be possible where these aggressive commercial methods are employed, and 50 cents to $2.50 appears to be the varying result in cities where they are not employed, that aggressive commercialism along the lines exploited in this campaign and in the trade papers would appear to be the missing link.

The aim would be, briefly, for the coming year to carry this part of the work along in such a manner as not to lose any of its cumulative effect.

ELECTRICAL CONTRACTORS AND DEALERS

A campaign of commercial literature will be issued to the electrical contractors and dealers, dealing with the subject of the extension of the business from their standpoint. This would be worked out along the same general lines as the previous campaign in the central station field, but adapted to their special conditions.

This campaign would closely dovetail in with the work of the special representative, as before described.

ARCHITECTS, BUILDERS, CONTRACTORS, REAL ESTATE DEALERS, ETC.

For the purpose of supplementing the work of the special representatives among the architects, builders, contractors and real estate dealers, a bi-monthly campaign of special advertising would be issued to 5000 architects, and, in addition, to the leading builders, contractors and real estate firms, which briefly would present forcibly the very great present and prospective utility of electric service for light, heat and power.

Work in this field will be conceded to be of a most fundamental nature. It is obvious that this line of work is important to all electrical interests, as a building correctly wired is almost a sure user of electric service. On the other hand, thousands of possible customers are at the present time lost on account of properties not having been wired during the last ten years. This loss will be all the more keenly felt and appreciated as increased efficiency develops in electrical appliances, which will make them more and more practicable for people in moderate circumstances, as appears to be the present outlook in the lighting field.

THE TECHNICAL PRESS

The technical press are deserving of the very greatest credit for the manner in which they have endorsed this entire co-operative commercial campaign through the opening up of new business departments in their papers. There can be no doubt that they have exerted a powerful influence in bringing about the results which appear to have been accomplished.

The association would aim to work as closely as possible with the technical press in every way, as they constitute an effective medium for reaching the distributing trade, along these lines.

It has been suggested that for the present commercial supplements should be issued, dealing with particular phases of the business-getting problem, and doubtless other uses will be found for their columns, on the basis of which the association will find it profitable to spend a reasonable amount of money with them.

PRIZES FOR ELECTRICAL SOLICITORS' HAND-BOOK

In the year 1906 the association offered $1000 for papers on the "Organization and Conduct of a New Business Department for Central Stations." Liberal responses were made to this offer and valuable papers were contributed, which have been made of the greatest possible use through publication during the past six months in the trade journals and by direct issuance to the trade in pamphlet form. This has worked out so satisfactorily that it has been deemed advisable to offer $2000 in prizes for the preparation of an "Electrical Solicitors' Hand-book," to be arranged in loose-leaf form suitable for carrying in the pocket. This prize money is divided as follows:—

$1000 for the light section, subdivided into $500, $300 and $200 for first, second and third.

$1000 for the power section, subdivided into first, second and third prizes of $500, $300 and $200.

$600 for the heat section, subdivided into three prizes of $300, $200 and $100.

The papers will be judged by a committee appointed by the president of the National Electric Light Association and the awards made at the next meeting of that association.

There is at the present time a very great demand for electrical solicitors, doubtless in consequence of the very greatly increased interest and activity in this field, and it is hoped that this book will serve, first, to stimulate present soliciting forces in competing for the prizes; second, that the final product will be a permanent value in the way of stimulating and instructing solicitors, relieving managers in many cases from the details of instructing solicitors.

Particularly among the medium-sized and small central stations the solicitors are drawn from the young men in the place, who frequently have had no experience in the electrical field. This book should be of very great assistance in these cases in rapidly whipping these solicitors into more effective salesmen.

It should also be valuable to managers of the smaller central stations, where the soliciting is done by the manager or employees having other duties to attend to.

NATIONAL COMMERCIAL PRESS BUREAU

I believe that this offers one of the most fertile fields for effective work in popularizing electric service. It obviously is one of the broadest lines of work which could be undertaken by the association, inasmuch as every line in the trade and everyone connected with the industry would be directly or indirectly benefited.

To go into this subject in any considerable detail would require a paper by itself. I cannot do better, however, in disposing of this subject, than to extract a paragraph from a paper presented before you by Mr. Ivy Lee, last March, on this subject:—

"Now there can be no question that electricity is one of the most interesting subjects in the world. Its application to our daily life is constantly becoming more widespread. This is an electrical age. The attention the world has recently given to the Cooper Hewitt light, the Marconi wireless telegraph and the Roentgen rays shows with what eagerness the public watches for every development of this current. Electricity will always have a large 'news value.' Even such well-known objects as the telephone and telegraph are constantly featured in the day's news. The interest in electricity is perennial. That is because it is transforming our modern life. The man interested has only to describe some 'novelty' of this marvelous transformation and it immediately becomes 'news.'

"To make the matter practical, Mr. Crouse asked me to demonstrate directly the possibilities of this kind of news service in behalf of electricity. As an instance of what might be done, a few weeks ago I sent throughout the country a description of the home of Mr. Hillman. You will find one of the results in the Cleveland 'Plain Dealer.' That article was printed all over the country. The Washington 'Post' used it in a very ingenious way. It published the article with a large display on one page, and on the page opposite, the business manager printed an advertisement of the local central station. This up-to-date, far-sighted manager evidently 'tipped off' the central station about the plans of the news page, so the manufacturer of current ordered the very extensive display advertisement, telling the public where they could get all the electrical devices mentioned in the news article. That was, to me, as striking an example as I ever saw of 'commercial publicity' supplementing the work of regular advertising. For, in the last analysis, the two things are very different and should aid one another.

"I am satisfied that if you were to establish through this new association what Mr. Crouse calls a 'National Electrical Press Bureau,' you could demand steadily a great deal of news space in the papers throughout the country. Your 'Electrical News' should tell of the novelties of the time, and of novel uses of old objects, showing in a very practical way, though not too pointedly, how any reader could make use of the same things himself.

"This would be publicity of the most valuable kind. The local central stations could follow it up directly. If conducted properly, the net results should be extremely satisfactory to the editors, the readers and the managers of the papers, as well as to those of you who are engaged in an industry which represents the latest practical benefits of science and progress."

ADVERTISING IN MAGAZINES AND PERIODICALS

This is likewise a line of activity which cannot be gone into effectively within the limits of time available to us. The proposition was effectively presented for your consideration at the last March meeting by a national expert in this field.

The following is extracted from his remarks at that time:—

"Conscious co-operation comes when all the people interested in producing electricity and producing the various instruments, machines, equipment, lamps, motors, heating devices, and the like, required to use electricity, get together and say:—'The more people there are who want electricity in some form or in all of its forms, the better for us; therefore, we will get together and spend money in educating the people to recognize electricity as the greatest modern helpmeet of business and domestic life.'"

This expert, in discussing magazine advertising as a general proposition, expressed the opinion that collective co-operative advertising by all the individual firms and corporations of a given industry in which the advantages of the use and service of devices are exploited on a general basis, disregarding the individual claims and individual differences of different manufacturers, is the sound and logical method to pursue, avoiding in this way unnecessary waste of competitive advertising in popularizing the service. In the long run the business resulting would doubtless reach the different interests concerned through the various distributing channels established in reasonable proportion to the expenditures incurred.

The campaign, as here outlined, would involve an expenditure of $151,550 during 1907.

MASSING OF SELLING EFFORT

In the field of mechanics the effort of the electrical and mechanical engineer is, among other things, to eliminate the loss and waste of friction. Is it not a fact that the conscious and unconscious effort of modern business must be to reduce the friction, loss and waste of competitive selling?

We may not reasonably hope, in our day and generation, to see much of a change made in a competitive system which is as old as the world, and which will only change on the basis of different motives actuating men's activities, and with a rapidity which is proportionate to the rate of change.

This proposition is, admittedly, an attempt in a very small degree to get away from competitive extension of a market, and to reap the advantages which must accrue when commercial effort is directed and massed, without competitive opposition from within, toward popularizing the service and extending the business.

We are proposing to get together

in this association on the basis of an assessment of approximately one-tenth of one per cent. on the output, a tax which can be in no view a particular burden to those who co-operate in the movement; but while it is small in the case of any individual company, it is readily seen that it makes a very large sum in the aggregate, and will render possible the prosecution of extensive plans for increasing the business.

The sales expense of electrical organizations, particularly the manufacturers, are keenly competitive. For every increase in selling expense, or increased gain in business, on the part of one manufacturer a corresponding effort is necessitated on the part of others, analogous to the maintenance of the navies and standing armies of nations.

This necessary competitive strain is very largely for business, either already existing or resulting from the normal growth in business generally.

This association, while it proposes no essential change in existing competitive trade relations, opens up a commercial programme which is logical and consistent, and where every dollar put into it will carry its full force and effect toward the extension of the business, not only without competitive opposition, but with the disposition on the part of all to see it do its full work.

It is further reasonable to anticipate that the evolution and growth of the association will tend to the general improvement and harmony in trade relations, which means again, within certain limits, increased selling and distributing efficiency.

Walter Cary was of the opinion that before the matter was presented to the manufacturers an organization should be effected. He, therefore, offered the following resolution, which was carried unanimously:—

"Resolved, That it is the sense of this meeting that the commercial programme outlined for the Co-operative Electrical Development Association for 1907 and the future is along sound lines, and gives good promise of highly profitable returns to all concerned.

"That it is the further sense of this meeting that immediate steps be taken to perfect the organization of the association, and to prosecute its commercial plans vigorously, pursuant to which the chair is requested to appoint three committees of five members each, as follows:—

"Committee on Constitution and By-Laws.

"Committee on Membership and Assessments.

"Committee on Commercial Programme."

Mr. McFarland then announced the following committees:—

COMMITTEE ON CONSTITUTION AND BY-LAWS

E. E. Jackson, Noble, Jackson & Hubbard.

A. D. Page, the General Electric Company.

Walter Cary, the Sawyer-Man Electric Company.

F. J. Newbury, the John A. Roebling's Sons Company.

W. W. Freeman, the Brooklyn Edison Company.

COMMITTEE ON MEMBERSHIP AND ASSESSMENTS

J. S. Anthony, the General Electric Company.

Walter Cary, the Sawyer-Man Electric Company.

W. W. Freeman, the Brooklyn Edison Company.

Charles B. Price, the Pettingell-Andrews Company.

James R. Strong, the National Electrical Contractor's Association.

COMMITTEE ON COMMERCIAL PROGRAMME

F. S. Terry, the National Electric Lamp Company.

W. C. Bryant, the Bryant Electric Company.

R. S. Hale, the Boston Edison Company

A. L. Doremus, the Crocker-Wheeler Company.

E. W. Gilmer, the Warren Electric & Specialty Company.

F. Bissell, the F. Bissell Company.

AFTERNOON SESSION

At the afternoon session Mr. Crouse read the proposed certificate of incorporation, the by-laws and constitution of the association.

CERTIFICATE OF INCORPORATION AND TENTATIVE BY-LAWS

The proposed certificate of incorporation and the tentative by-laws suggested for the Co-operative Electrical Development Association are given below. They have been prepared by the legal department of Henry L. Doherty, whose liberal co-operation in this, as well as in other phases of the development of the entire movement, is gratefully acknowledged.

They are not presented, by any means, as a finality in the way of a plan of organization, but it is hoped that it will form a fairly concrete text for further careful consideration.

CERTIFICATE OF INCORPORATION OF CO-OPERATIVE ELECTRICAL DEVELOPMENT ASSOCIATION

We, the undersigned, all being persons of full age, and all being citizens of the United States, and at least one of whom is a resident of the State of New York, desiring to form a corporation for the purposes hereinafter set forth, pursuant to the provisions of the membership corporations law entitled "An Act Relating to Membership Corporations," approved May 8, 1895, as amended from time to time, do hereby make, sign and acknowledge this certificate and do hereby certify:

First—The name of the proposed corporation is Co-operative Electrical Development Association.

Second—The objects and purposes for which the said corporation is formed are for the promotion of the increased and more extended use of electric current by the public for light, heat and power as an end in itself, and a means to increased demand for apparatus and supplies, and the co-operative planning and execution of various means and methods effective to this end; the establishment of co-operative relations, both moral and financial, among the different electrical interests, from the manufacturer to the consumer, to the end that each may contribute in some measure toward bringing about the above results desired in common by all, and the mutual co-operation, benefit and protection of its members. In furtherance of its said objects and purposes, it shall have power to purchase and acquire in the State of New York, and elsewhere, such real and personal estate and property as may be necessary or proper, and to mortgage the same to secure the payment of any bonds which may be issued by the corporation, and generally to do any and all things which may be necessary or proper in connection with its objects and purposes, which may not be contrary to law. The corporation is not to make a profit, not to make or declare dividends, and is not to engage directly in the business of selling electric current, or manufacturing or selling electrical machinery or apparatus.

Third—The territory in which the operations of the corporation are to be principally conducted is within the limits of the United States of America and its territories and possessions, and Canada and Mexico, but it is also to have power to conduct such operations in part outside of the limits of the United States, so far as may be necessary in accomplishing the objects and purposes of its organization.

Fourth—The principal office of the corporation is to be located in the borough of Manhattan, city, county, and State of New York.

Fifth—The duration of such corporation is to be perpetual.

Sixth—The number of directors of such corporation is to be twenty-seven. Until the first annual meeting the number of directors shall be nine.

Seventh—The annual meeting of the members may be called by the officers with the approval of the directors, the same to be held at such times and places as may be approved by the directors, and may be held within the State.

BY-LAWS—ARTICLE I.—MEMBERS

1. Active Members.—Any individual, firm or corporation engaged in the manufacture, construction or sale of electrical or other apparatus and supplies necessary to the production, distribution, or utilization of electric current for light, heat or power, or in the sale of electric current for these purposes, shall be eligible to active membership upon payment to the association at stated periods during a period of three years, of such an amount as may be determined upon and provided for in the by-laws.

2. Associate Members.—Any individual, firm, or corporation, association, or society shall be eligible to associate membership subject to such conditions as may be incorporated in the by-laws relative to eligibility, rights, duties, etc.

3. Honorary Members.—Any individual shall be eligible for honorary membership whose practical and scientific knowledge of the electrical arts would recommend them to the association.

ARTICLE II.—OFFICERS OF THE ASSOCIATION

1. The officers of this association shall consist of a president, two vice-presidents, and a secretary-treasurer, whose appointments, terms of office, duties, etc., shall be prescribed by the by-laws. It is provided, however, that no person shall be elected as an officer of this association who holds an official position with a membership company.

2. There shall be twenty-seven managing directors, elected by, and selected from the active members.

The managing directors shall be so grouped into classes that the terms of one-third of them shall expire each year. It is provided, however, that the first board of directors shall consist of nine members, and shall be added to from time to time with the growth of the association, on the basis of the membership assessment as set forth in the by-laws.

The number of managing directors shall not at any time exceed twenty-seven, and at such time as the membership assessments would increase the number of managing directors above twenty-seven, the basis of representation shall be adjusted to keep the number at twenty-seven.

Active members, individuals, firms or corporations shall be represented on the board of managing directors on the basis of their membership assessments, as may be provided for in the by-laws.

3. There shall be advisory directors, consisting of representatives of electrical associations, societies, or others (not eligible for active members) who may, at the request of the officers of the association, be appointed by their respective bodies to represent them, and to assist by their counsel, advice, and moral co-operation in carrying out the objects of the association.

The method of appointment, term of office, duties, etc., shall be prescribed in the by-laws.

ARTICLE III.—MANAGEMENT

1. The active management of the affairs of the association shall be entrusted to the officers, subject to such limitations as may be prescribed by the board of managing directors.

2. A majority of the number of officers and managing directors representing at the same time not less than a majority in amount of the membership assessments, shall constitute a quorum for the transaction of business.

ARTICLE IV.

The officers and managing directors shall have power to enact, amend, and enforce all necessary by-laws and rules, and to provide penalties for their violation.

ARTICLE V.—MEETINGS

1. An annual meeting of the active, associate, and honorary members, by classes, or collectively, may be called by the officers, with the approval of the directors at such times and places as may seem desirable.

2. Regular meetings of the officers and directors shall be held not less than twice a year, on the second Wednesday of September and the second Wednesday of February, at the office of the association or some other place designated by the president for the transaction of necessary business.

ARTICLE VI.—OFFICERS, HOW ELECTED, DUTIES, ETC.

1. All officers shall be elected by the vote of a majority of the managing directors, representing not less than a majority in amount of the membership assessments. The officers shall be elected for such periods as the board of managing directors may decide upon, or until their successors are duly elected and qualified. Their remuneration shall be fixed by the board of managing directors.

2. President.—The president, or in his absence the vice-presidents in order, shall preside over all meetings of the association and the board of directors; he shall enforce all rules of the association; he shall appoint all committees not otherwise provided for; he shall decide all questions of order subject only to an appeal, but in all cases it shall require the vote of at least a majority of the managing directors, representing not less than a majority of the membership assessments, to overrule his decisions; he shall have general management and supervision of the work of the association and submit at the semi-annual meetings of the directors a detailed report on progress and plans, which report shall be in addition transmitted to the active members, and, at his discretion, to the associate and honorary members; he shall have authority to enter into alliances and contracts for service of various kinds tending to promote the interests of the association—provided, however, that he shall not enter into any contract for the expenditure of ten thousand ($10,000) or more, except on the approval of a majority of the officers and directors, representing at the same time not less than a majority of the membership assessment, such vote being secured either in writing, or at a semi-annual meeting; and, provided further, that no expenditure of any kind shall be incurred for which there are not sufficient funds in the treasury, or due on membership assessments to meet the same, outside of the reserve fund hereinafter provided for.

No moneys shall be paid out, nor obligations of any sort incurred without the approval and counter signature of the president.

4. Vice-Presidents.—In the absence of the president, the vice-presidents, in order, shall preside at all meetings and perform the customary duties of the president.

5. Secretary-Treasurer.—The secretary-treasurer shall attend all meetings of the association and board of directors; he shall have charge of the records, files, reports, accounts, assessments, funds and other papers and

properties of the association, performing, in addition, the customary duties of the office and any others delegated by the president. He shall, not, however, have any authority to pay out moneys or incur obligations of any sort on behalf of the association except on the written approval of the president.

ARTICLE VII.—RESERVE FUND

1. From the funds received from the membership assessments there shall be annually set aside 10 per cent. of the same as a special reserve fund, and this shall be continued until such reserve fund has reached an amount equal to the average annual expenditure of the association for the three preceding years, or one hundred thousand dollars ($100,000) until such average may be arrived at.

2. This fund shall be held as a savings account or invested in safe securities, on the instructions of the officers and managing directors, for the purpose of insuring that the work of the association may be carried on without serious interruption during periods of business depression and disturbance which might cause a lapse in membership.

ARTICLE VIII.—MEMBERSHIP ASSESSMENT

1. The membership assessment for active members shall be approximately one-tenth (1-10) of one (1) per cent. on their sales of electric current, or electrical or other apparatus and supplies necessary to the production, distribution, or utilization of electric current for light, heat or power other than in connection with electric traction work, the same to be paid in during a period of three years, subject to the detailed terms of the membership contract.

2. The above, which shall be the basic rule for membership assessments, may be varied at the discretion of the officers and managing directors in particular cases, if found not to be equitable and fair, by a vote of the majority of the officers and managing directors representing not less than a majority in amount of the membership assessments.

3. Similarly, by a vote of a majority of the officers and managing directors, representing not less than a majority in amount of the membership assessments, membership may be accepted from individuals, firms, or corporations on the basis of the payment of approximately one-tenth (1-10) of one (1) per cent. or other percentage on their sales of electric current, or some one line of electrical or other apparatus and supplies as above described less than their entire output of such electric current, or electrical or other apparatus and supplies.

4. The above membership assessment of approximately one-tenth of 1 per cent. or other percentage on sales as described may be varied either by increasing or reducing, by the vote of a majority of the officers and managing directors, representing at the same time not less than a majority in amount of the membership assessments, such change to become effective on Jan. 1 of the succeeding fiscal year, and to become effective upon all active members pro rata.

ARTICLE IX.—OFFICIAL SYMBOL

The official symbol of this association shall be a magnet with the word "Co-operation" inscribed on the upper semi-circle, three dollar marks ($$$) appearing on the plate, and the initials "C. E. D. A." across the face.

ARTICLE X.—QUORUM

A quorum of officers and managing directors for the transaction of any business shall consist of not less than a majority of the officers and managing directors representing not less than a majority in amount of the membership assessments.

ARTICLE XI.—BOARD OF DIRECTORS

The annual payment into the association of five thousand dollars ($5000) in membership assessments by a single individual, firm or corporation, or a group of individuals, firms or corporations, shall entitle such individual, firm or corporation or group of same to one managing director.

The board of officers and managing directors shall meet semi-annually on the second Wednesday of September and February, and shall inspect and review the affairs of the association, following the regular order of business as provided in the by-laws as to meetings, Article V.

The board of officers and managing directors shall either elect a finance committee of three, or arrange with public accountants to thoroughly examine and audit at any time, and not less than annually, the records, accounts, or other affairs of the association, reporting to the board at the next meeting.

ARTICLE XII.—EXPULSION

Any officer, director, or active associate, or honorary member, in the judgment of the officers and directors, found violating the rules and regulations of the association, or acting in a manner prejudicial to the objects of the association, may be expelled from the association by a vote of a majority of the officers and managing directors, representing not less than a majority in amount of the membership assessments, thereby losing all rights and privileges of active or other membership, provided, however, that any such accused officer, director, or member shall be furnished with a copy of the charges against him at least ten (10) days before action is taken, and be authorized to appear either in person or by counsel in his defense.

ARTICLE XIII.—RULES OF ORDER

"Robert's Manual of Procedure" shall govern in all cases not herein provided for.

ARTICLE XIV.

Special meetings of the members, directors, and officers may be called at the discretion of the president, at which only the matter for which the meeting was called shall be considered.

ARTICLE XV.—REPORTS

The president shall make quarterly reports of progress and plans to the active members, and, at his discretion, to associate and honorary members, such reports to be issued as of the dates of the regular quarters of the fiscal year.

ARTICLE XVI.—FISCAL YEAR

The fiscal year of the association shall be from Jan. 1 to Dec. 1, and the fiscal quarters from Jan. 1 to March 31, April 1 to June 30, July 1 to Sept 30, Oct. 1 to Dec. 31.

ARTICLE XVII.—CHANGES OF BY-LAWS

1. These by-laws may be altered or amended as follows:

2. Any proposition to alter, amend, or repeal any existing by-law shall be presented in writing during a meeting of the officers and board of directors at any time before adjournment, seconded by not less than three officers or directors, shall be read twice, and if approved by a majority of the officers and managing directors, representing not less than a majority in amount of the membership assessment, shall become part of these by-laws; but no such alteration or amendment shall affect any question pending at time of its adoption.

3. Any additional section of these by-laws not in conflict with any existing by-laws or the certificate of incorporation may be adopted at any regular meeting of the officers and managing directors upon being presented in writing, duly seconded, twice read and approved by a majority of the officers and managing directors, representing not less than a majority in amount of the membership assessment.

American Institute of Electrical Engineers

PAPERS READ AT THE NOVEMBER MEETING IN NEW YORK

New Types of Incandescent Lamps

BY CLAYTON H. SHARP

FOR a number of years the standard of electric lighting has been set by the carbon-filament lamp, consuming initially 3.1 watts per candle-power. Progress there

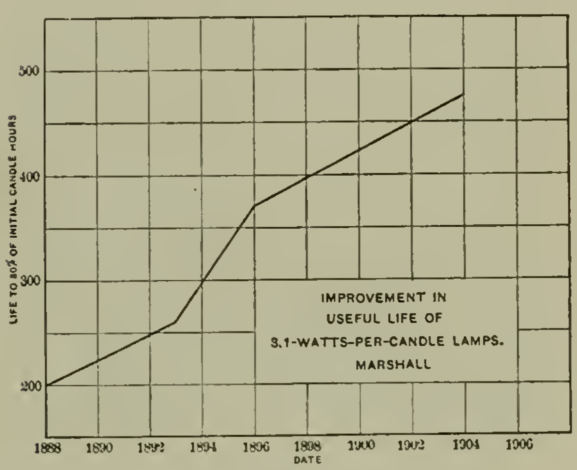


FIG. I

has been, but chiefly in the way of minor improvements in the process of manufacture, rating of lamps, and in the way of a more general adoption by electric lighting companies of the 3.1-watts-per-candle lamp.

This watt-per-candle consumption has been recognized as the minimum practicable under good operating conditions. Any radical or considerable improvement in the lamp itself has seemed improbable of attainment. The degree of improvement which has been made in the carbon filament lamp has been indicated by data given by J. T. Marshall in a paper before the Franklin Institute*. The continuous increase in the effective life of incandescent lamps burned at 3.1 watts per candle between the years 1888 and 1904, as given in Marshall's paper, are shown in the curve, Fig. 1. The effective life at the present time is seen to be substantially two and one-half times as great as the life in 1888.

The advent of the osmium lamp cannot be said to have altered the state of affairs materially. In spite of its very high efficiency and long life, this lamp seems precluded from exercising any revolutionary influence on lighting practice, on account of its low voltage, and, most of all, by the limitations of the visible supply of the material of which the filament is composed.

Within the last two years the situation has altered materially. A marked improvement in the process of manufacture of carbon-filament lamps, which has been announced and described by John W. Howell before this Institute,* has resulted in the commercial production of lamps which operate on a 2.5-watts-per-candle basis instead of a 3.1-watts-per-candle basis.

A German firm, going back to the class of materials employed in the earliest attempt at the manufacture of incandescent electric lamps, has produced a lamp with a wire of tantalum as the glowing body, and with an efficiency greatly in advance of that of the established carbon filament. More recently still, various experimenters have succeeded in producing lamps with a filament of metallic tungsten which carry the standard of efficiency to a point far beyond that obtainable with either carbon or tantalum. Since the graphitized or "metallized" carbon filament has in this country become a regular commercial product, the properties of which are moderately well known, it is deemed best in this paper to take up more in detail the peculiarities or the properties of the tantalum and the tungsten lamps.

PROCESSES OF MANUFACTURE

It is not necessary in this place to go into a discussion of the process of manufacture of the filaments of the metallized carbon and of the tantalum lamp, nor of the appearance of the lamps themselves, since these have become quite well known. In the case of the tungsten lamp, certain peculiarities of the construction are made necessary by the properties of the tungsten filament itself.

The metal tungsten (German "wolfram") while ordinarily reckoned as one of the rare elements, yet is from the point of view of lamp

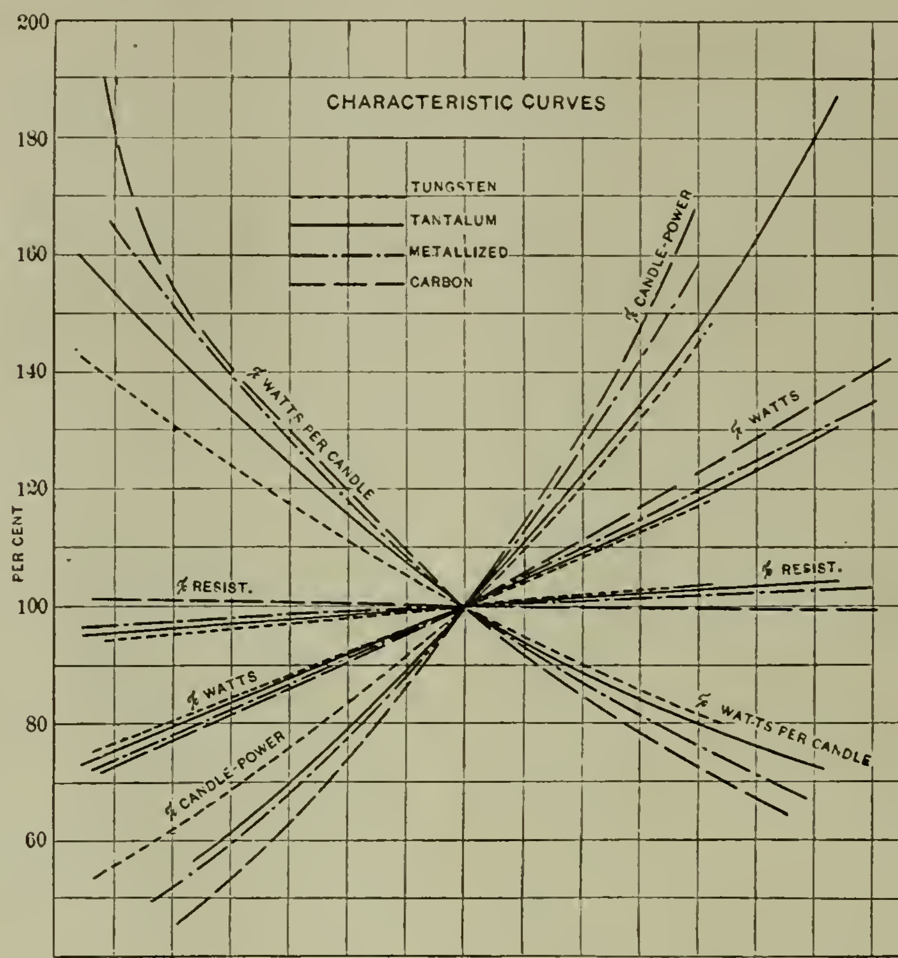


FIG. 2

* Journal of the Franklin Institute, 1905, vol. CLX., page 21.

* Asheville convention paper, 1905.

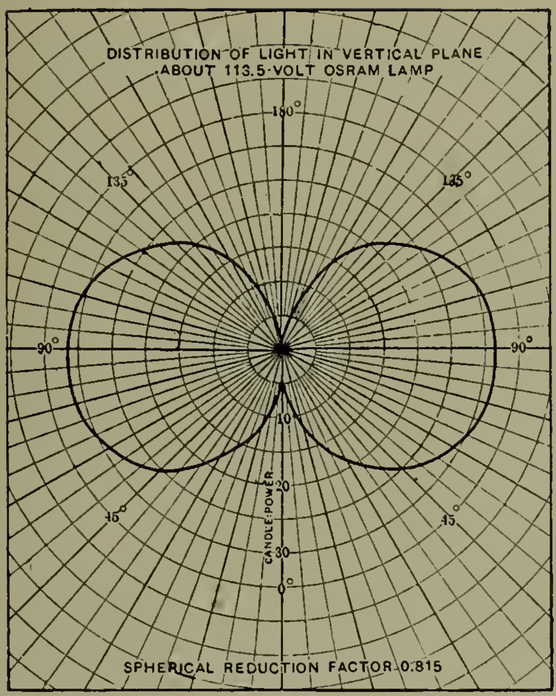


FIG. 3

manufacture quite plentiful enough for all practical purposes. While its price per pound is high, yet considering the weight of the metal entering into an incandescent lamp, it is not especially expensive. One of its most important uses at the present time is the production of tungsten steel. The metal is infusible by any ordinary process. The melting point of tungsten filaments has recently been given by Waidner and Burgess at 3200 degrees Cent.

The metal is commercially obtainable in the form of a fine powder. Tungsten does not seem to be ductile, so it is impossible to draw it directly into a fine wire, as is done successfully in the manufacture of the tantalum filament. It unites readily with oxygen and with carbon at high temperatures. These peculiarities have made the problem of the production of tungsten filaments a rather difficult one. It has been atacked from several sides, and different processes for the manufacture of tungsten filaments have resulted.

The earliest process to be brought to public attention was that of Dr. Kuzel. Kuzel's process consists in the production of a colloidal solution of tungsten by forming an arc between terminals of the metal under the surface of water. The colloidal solution, when it has been brought to the proper consistency, is squirted through a die into filaments, which, after being dried, are converted from the colloidal condition into the crystalline condition by the passage of an electric current through them. In this way the filament is produced without introducing any carbon, which would unite with the tungsten to form tungsten carbide, a compound which is readily formed and which moreover is very detrimental to the quality of tungsten filaments.

Another process is the substitution process of Drs. Just and Hanaman. This process seems to be very similar to one patented by Lodyguine some ten years ago. In this process a very fine carbon filament is heated in an atmosphere of a chloride of tungsten and hydrogen. Under proper conditions of the experiment, tungsten is deposited upon the carbon filament, the hydrogen acting as a reducing agent. By heating the filaments by means of a current, the whole filament is converted into tungsten carbide. The carbon made is then removed from the filament by heating it in an atmosphere of steam and hydrogen. The steam is decomposed, its oxygen uniting chiefly with the carbon of the carbide.

Whatever tungsten is oxidized in this process is reduced again by the

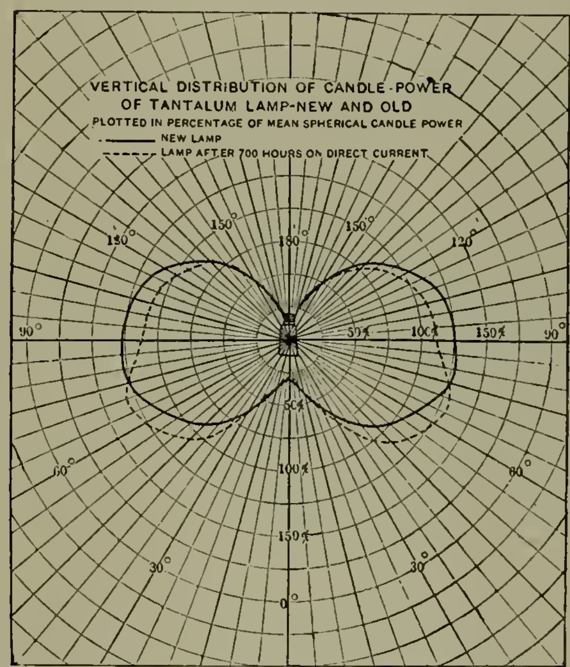


FIG. 4

hydrogen which is present. It is impossible to say exactly whether this process is actually used in the manufacture of these lamps or not, though the statement may be made with a reasonable degree of certainty that some substitution process is used by Drs. Just and Hanaman.

The manufacture of filaments of osmium presented a problem similar to that of the tungsten filament. It is, therefore, natural that the process of Dr. Auer von Welsbach should, by proper modification, be adapted to the manufacture of tungsten lamps. Experiments along this line have been carried on by the companies in Germany and Austria which have been engaged in producing osmium lamps. To the tungsten lamp manufactured by the Osmium Lamp Company, of Vienna, has been given the name of the Osmin lamp. The tungsten lamp of the Auer Company, of Berlin, is called the Osram lamp.

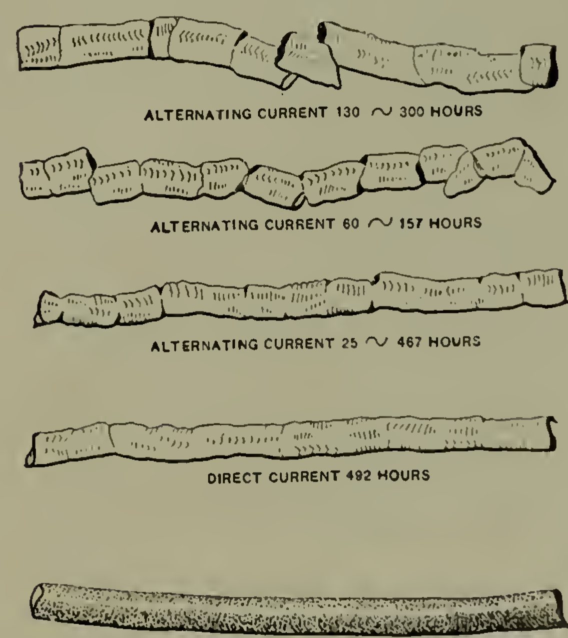
While it is reasonably certain that the details of the processes of manufacture of these two lamps differ from each other, yet they are probably alike in their general features. The method consists in forming a paste of finely-divided tungsten with a binder of organic material, such as, for instance, sugar solution, and squirting it into filaments through a die. The carbon is then removed from the filament by heating the latter in an atmosphere of steam and hydrogen or by the use of some similar process.

Still another tungsten lamp is known as the "Z" lamp. The process by which it is manufactured involves also a squirting of a paste consisting of finely divided tungsten with an organic binder, but differs from the other in the method employed to remove the carbon.

A well-known manufacturing company has announced that it is about to put a tungsten lamp upon the market, made by a process differing from all those mentioned above, but no information as to the nature of this process is available.

It has also been announced that John A. Heany has been successful in producing tungsten lamps, but details as to his method of operation are also entirely lacking. Some lamps made by Mr. Heany have been the subjects of experiments made at the National Bureau of Standards.

It will be seen from the foregoing that the possible methods for producing tungsten lamps are probably quite numerous, and that the prospects are that we shall have in the near future a number of competing processes of varying degrees of merit. Time and experience will be required to show which is best adapted to practical application.



NEW LAMP
THE TANTALUM FILAMENT

FIG. 5

PHYSICAL CHARACTERISTICS

Tungsten lamp filaments manifest all the ordinary properties of wires of pure metals. They have high

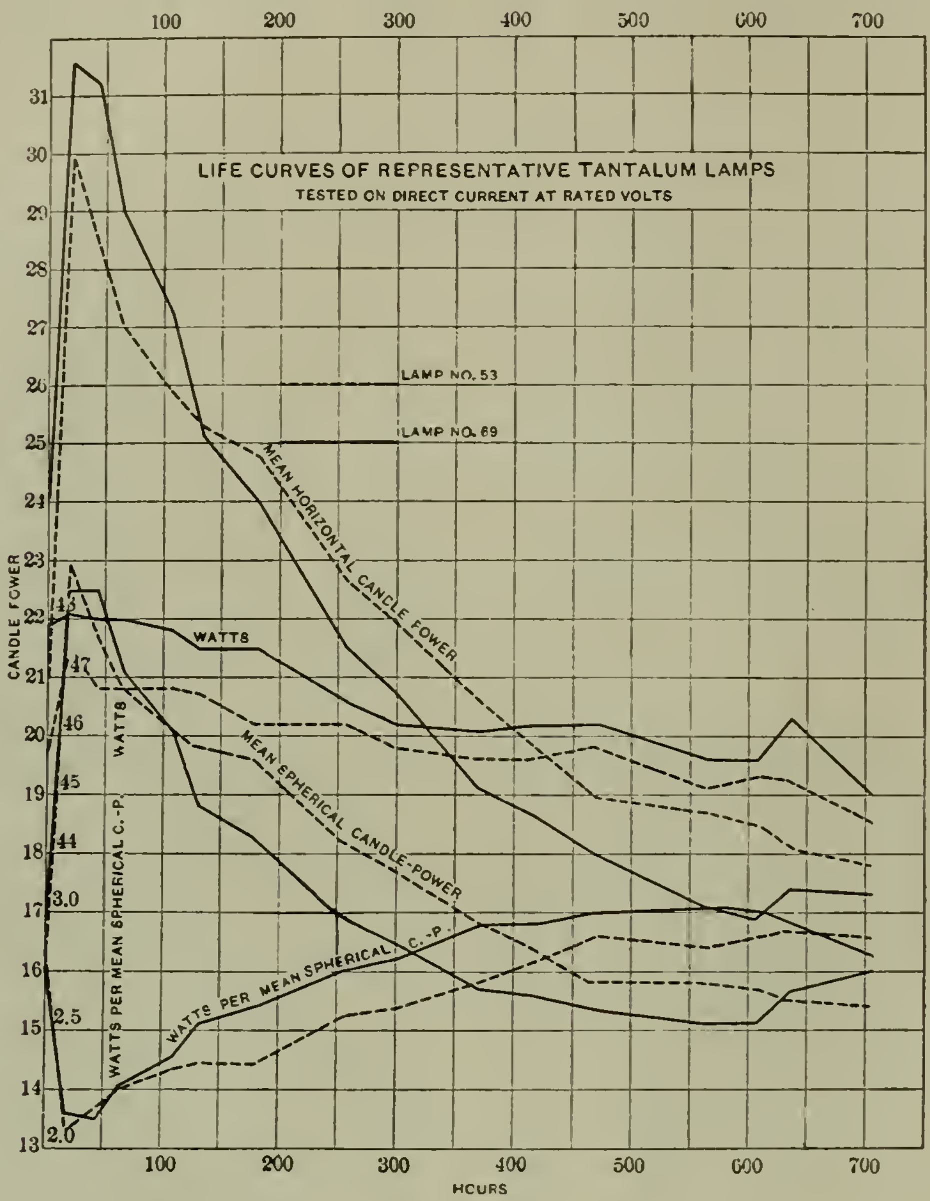


FIG. 6

conductivity and a large, positive temperature coefficient. The high conductivity of the material requires that the filaments shall be very fine and quite long if they are to be used in producing lamps giving a reasonably low candle-power on 110-volt circuits. The degree of fineness to which it has been possible to reduce these filaments is indicated by the following table:—

	Diameter
Tantalum, 110 volt, 22 c-p.	0.052 mm
Osmium, 16 volt	0.103 mm
Z New	0.1 mm
Z After burning	0.055 mm
Osram, After burning	0.044 mm

A fine hair may have a diameter of about 0.06 mm. In view of the extraordinary degree of fineness which has already been attained in the manufacture of these filaments it does not seem probable that very much more can be looked for in this direction.

Tungsten filaments, when at the temperature of full incandescence, are quite soft. It is, therefore, not feasible to produce them and mount them in lamps in any other form than that of loops. The ends of each loop are attached by means of a paste or by actually fusing them fast by the use of an electric arc to wires brought out from the stem of the lamp. The stem of the lamp is prolonged and carries at its lower extremity wires which serve as guides and supports for the loops of the filament.

All the lamps which have been exhibited up to the present time have been intended for burning only in a pendant position. It can be stated, however, that by certain modifications in the details of construction lamps are now being made which can be burned in any position. The first tungsten lamps produced were designed for low voltages. In consideration of the high conductivity of the material, the production of a low-voltage lamp is a more simple problem than the production of one of higher voltage, since for low voltages a shorter length of the filament may be employed. It would seem also that it is easier to produce a lamp of high candle-power than of low candle-power, since a stouter filament may be employed in the high candle-power lamp.

As far as the writer knows, no 110-volt lamps have been produced yet for lower candle-powers than 25, and no lamps have been produced for higher voltages than 220. The fineness of the 110-volt, 125-candle-power filament is such that it would seem to be difficult to produce such a lamp as a regular commercial article. The 220-volt lamps are probably yet only experimental.

The properties of the tungsten filaments are such that it would seem to lend itself very readily to the production of very excellent lamps for street lighting by the series incandescent system. Lamps for 110 volts are likely, when commercially produced, to have a watt consumption of 50 watts or more. If tungsten lamps are to be made for small candle-powers, such as are commonly employed in domestic lighting, they would probably need to be made for 50 volts or under, and consequently either burned in series or connected to low-voltage mains.

One of the chief disadvantages of the tungsten lamp lies in the extreme fragility of its filament. Blows or shocks given to the lamp are quite likely to cause a rupture of the filament. A ruptured filament may, however, mend itself by the parts welding together once more, but where the filament has become welded it is quite likely to break loose again.

ELECTRICAL CHARACTERISTICS

The features which differentiate the electrical behaviour of the newer lamps from the ordinary carbon lamp is their positive temperature coefficient. The temperature coefficient of

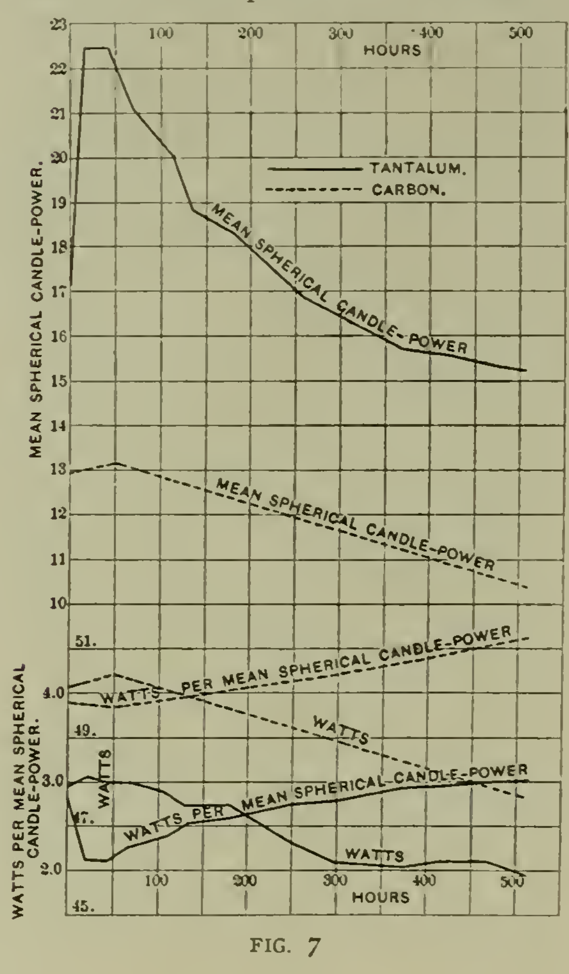


FIG. 7

the ordinary treated carbon filament has been shown by John W. Howell to be very nearly zero at the temperature of ordinary incandescence. At lower temperatures its coefficient is negative.

The term "metallized" has been given to the carbon filaments treated by the high-temperature process on account of the fact that these filaments at their temperature of incandescence have a positive coefficient. The tungsten and tantalum filaments have also positive coefficients which are, moreover, much larger than the positive coefficient of the "metallized" carbon. The temperature coefficients of tantalum, osmium, and tungsten filaments have been determined by measuring the resistance of these filaments at room temperature and again at 100 degrees centigrade. The coefficients as found were as follows:—

	Per Cent. per Degree
Tantalum	0.234
Osmium	0.372
Tungsten (Osram lamp)	0.438

It will be noted that the temperature coefficient of the osmium filament corresponds very closely to the temperature coefficient of pure platinum. The temperature coefficient of the tungsten lamp is higher and that of the tantalum filament is lower than the average coefficient for pure metals. In accordance with the general law that the presence of impurities reduces the temperature coefficient to a very marked degree, it would appear that the tungsten of the Osram lamp was very pure, while the tantalum of the tantalum lamp either contained some slight trace of impurity or that the metal was in such a condition, due possibly to crystallization or to lack of annealing, that its coefficient was abnormally low.

The effect of the positive coefficient is to give the metal-filament lamps considerable inherent regulation. That is, the change of current through the lamp is no longer proportional to the change in voltage, but is smaller proportionally than the change in voltage. Consequently, in watts, candle-power, and watts per candle, these lamps undergo smaller changes with the change in the line voltage than is the case of the carbon-filament lamp. These characteristics are brought out in the curves of Fig. 3. From the data used in plotting the curves the following table has been taken, showing the change in candle-power and in the watts per candle of carbon, metallized, tantalum, and tungsten lamps with 5 per cent. rise in the voltage:—

The quality of the lamps here pointed out is a very valuable one, since it must have two important results:—

First, the light of the lamps is less affected by bad regulation of the

FIG. 8

circuit. This means that with a given degree of regulation of the voltage on the circuit, the service must be more satisfactory to the user, and has a direct bearing on the amount of copper required in feeders.

Second, the life of these lamps is probably less affected by the mo-

TABLE III.

Change with 5 Per Cent. Increase in Voltage Above Normal

	Candle-power, Per Cent.	Watts per Candle, Per Cent.
Carbon	+30	—15
Metallized	+27	—13
Tantalum	+22	—11
Tungsten	+20	—10

mentary or even continued application of excessive voltages.

Another interesting consequence of the positive temperature coefficient is that at the instant of closing the circuit the current through a metallic filament is much greater than it is a fraction of a second later when the current has had time to heat the filament to its normal temperature. In other words, there is an initial inrush of current similar to that experienced in an arc lamp or in a motor, but enduring for a much smaller period of time. The behaviour of the ordinary carbon filament is the reverse of this.

On closing the circuit, the instantaneous value of the current through the tantalum lamp is very high, but decreases with great rapidity. The instantaneous value of the current through the carbon filament is much lower, and gradually reaches its maximum value. The consequences of this can be perceived by the eye. Since the initial inrush into the metallized filament causes it to come to full incandescence much more quickly than does the carbon filament, the relative sluggishness of the carbon filament is readily appreciated by the eye when the metallic filament and the carbon filament lamp are lighted up side by side on the same circuit.

DISTRIBUTION OF LUMINOUS INTENSITY

The distribution of luminous intensity in the horizontal plane for both tantalum and tungsten lamps must be on the average a circle, due to the method of construction of the lamps. This circle contains in each case a number of narrow maxima,

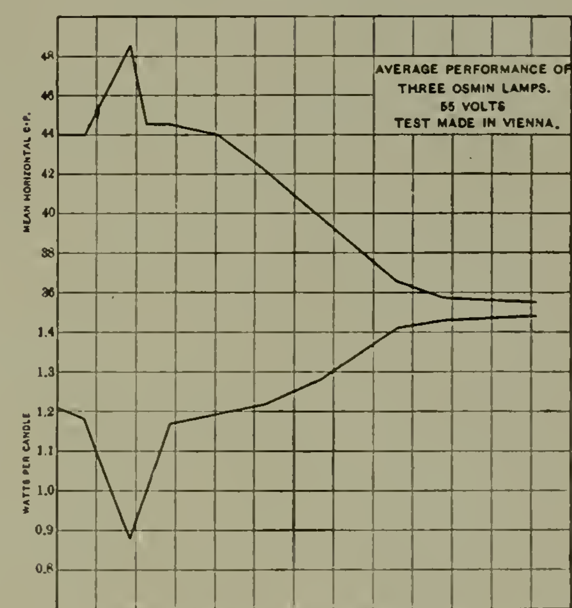


FIG. 9

which are due to reflections from the opposite side of the bulb. Curves of vertical distribution of a tungsten lamp and of a new and an old tantalum lamp are shown in Figs. 3 and 4.

The difference between the curves of the old tantalum lamp and the new tantalum lamp brings out a marked peculiarity of the tantalum lamp when constructed with a microscope, a uniform surface, except for very slight pittings. A wire of this sort would radiate very little in directions nearly parallel with its length. The law which applies to a body having a perfectly black surface is that the radiation is proportional to the cosine of the angle of

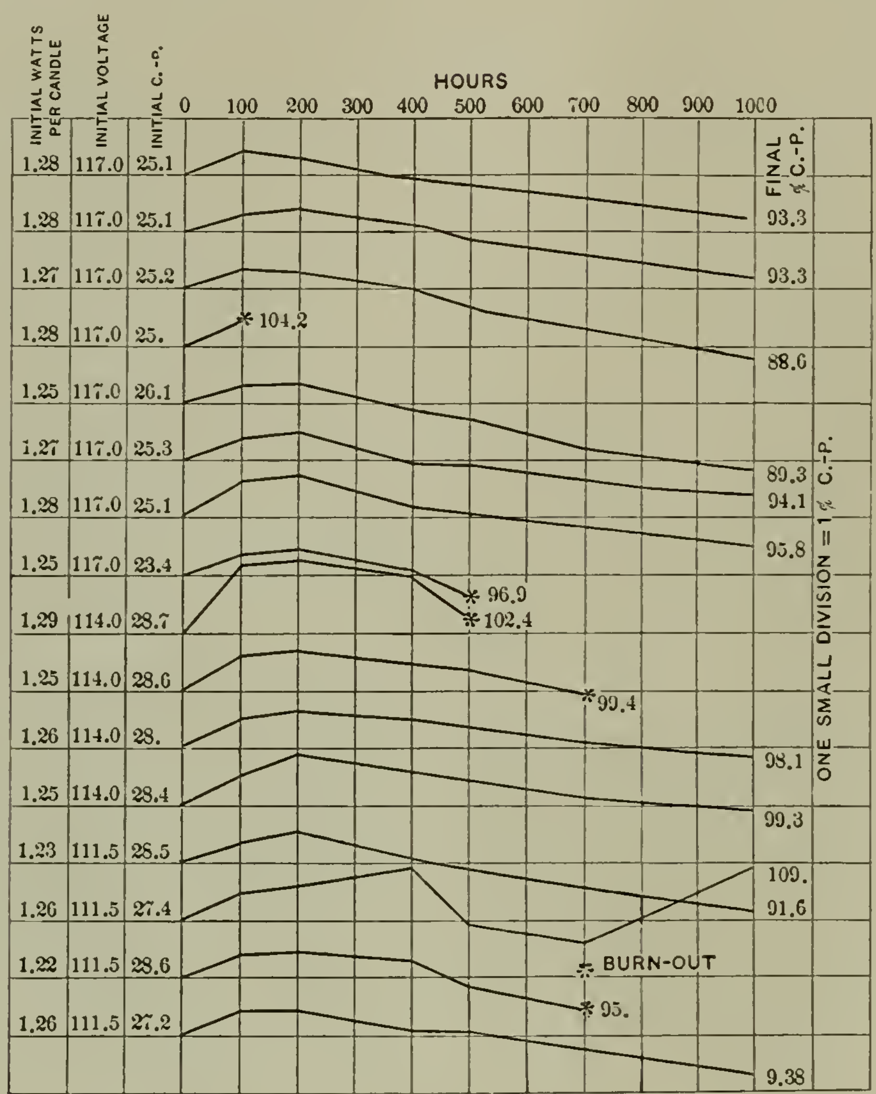


FIG. 10

straight-sided bulb. It points to a change in the spherical reduction factor or ratio of the mean spherical to the mean horizontal candle-power of the lamp during its life. Such a change is actually shown by the lamp. The change in vertical distribution may be traced to two causes; first, to the fact that during the course of the burning of the lamp a heavy deposit of black material is left on the bulb in a zone of a width substantially the same as the length of the spires of filament stretched between their support. This zone of blackening decreases strongly the horizontal intensity of the lamp, and much less strongly the intensity in the direction of the tip. Hence, the candle-power as measured through the tip becomes relatively stronger as time goes on.

Another cause of this change is probably the increased roughness of the filament of the lamp. When the lamp is new, the filament appears as a fine, smooth wire, looking like polished steel, and showing, under the emission of the rays. The radiation from such a body as the tantalum filament would decrease more rapidly than according to this cosine law, consequently there would be a deficiency of light in directions not at right angles to the filament. The filament, however, becomes roughened with use, and the little projecting surfaces would tend to increase the radiation in these directions.

USEFUL LIFE OF METAL-FILAMENT LAMP

It has been customary to consider as the useful life of a carbon-filament lamp its life up to the time when its candle-power has fallen to 80 per cent. of its initial value. Beyond this point it has been considered cheaper to discard the old lamp and replace it with a new one; in other words, this has been taken to be the proper "smashing point" of the lamp.

It should be pointed out that this relation does not hold with metallic-filament lamps. The smashing point of a lamp is determined by considerations of initial cost of the lamp, the cost of electrical energy, and the rate of decline of the candle-power of the lamp. In the metallic-filament lamps we have lamps of much higher economy, not only initially, but throughout their life; they are lamps of higher candle-power and necessarily of higher initial cost. It would seem that the data at present available regarding such lamps are not sufficient to permit of the proper determination of the smashing point. Certain it is, however, that where such lamps are used they are likely to be burned until they fail. This is the condition which is almost necessarily brought about by their relatively high cost.

A feature which marks both the tantalum and the tungsten lamp is the ability of the filaments sometimes to repair themselves after having been broken. If the broken end of a filament becomes crossed with another portion of the filament so that the electric circuit is completed the lamp once more lights up. In the case of the tantalum lamp, a junction of this kind may result in a very strong weld, so that a point of this sort does not necessarily constitute a point of especial weakness in the filament. Welds of this sort between tungsten filaments operated at normal voltages are much less secure and are quite liable to break apart. After a repair of this sort the candle-power of the lamps is usually higher than before, due to the decreased length of filament which the current must traverse.

LIFE HISTORY

Some of the earliest tests of tantalum lamps made in this country showed a much poorer behaviour than was claimed for the lamp by its makers. In these tests the lamps were burned on alternating-current circuits. Since there was no reason to suspect that the lamps were suffering on account of incorrect voltage or rough handling, the conclusion was almost inevitable that the nature of the current might be influencing their life.

On trial, it was found that tests made on direct current instead of alternating gave results which were in general agreement with those which had been published abroad. Since that time the effect of alternating current in shortening the life of a tantalum lamp has become well recognized.

A microscopic examination of the tantalum filaments, new and burned on direct current and alternating current of different frequencies, is extremely interesting. A free-hand drawing of such filaments as seen under the microscope is given in Fig. 5. It will be seen in this figure that the unused filament is smooth and polished, with only slight pittings on the surface. The filament which has been burned on direct current is much less regular; its surface shows deeper pittings, and, in places, it is cut and notched as if with a knife blade. Some parts of the filament are much more irregular than others.

The filament on 25 cycles shows still stronger markings of the same character as shown on the direct current, but shows also, in places, a jointed structure looking like that observable sometimes in basaltic rocks. This latter effect is even more marked in the case of the filament which has been run on 60 cycles. Here, parts of the filament look as if they were made up of blocks which had been irregularly piled one on the other. The length of these jointed sections in the filament is about equal to the diameter of the filament itself. It looks, in some places, as if one of these sections had been almost expelled from the row. The appearance, too, is very much as if where these joints occur the filament had actually separated and had welded itself together instantly.

The filament which had been operated on 130 cycles had the same appearance, perhaps somewhat exaggerated. In short, the increased wear and tear of the filament, due to the use of the alternating current, is very apparent. The reason for it, however, is obscure. The conclusion is inevitable that this lamp at the present time is essentially a direct-current lamp.

No such effect is observable with the tungsten lamps. Tests of the Electrical Testing Laboratories show quite definitely that their life on direct current and alternating current is the same. This has also been proved by elaborate experiments to be true of carbon filaments.

Data on representative tantalum lamps, the performance of which may be considered to be characteristic, are plotted in Fig. 6.

The life-history of tantalum lamps is characterized by a large initial increase in candle-power and a corresponding decrease in watts per candle, the extreme values being reached at the end of about twenty-five hours. From this point on, the candle-power decreases at a moderately rapid rate and the watts per candle increase. The rate of decline of the mean horizontal candle-power is more rapid than that of the mean spherical candle-power, for the reasons given above. The result of the relatively slow decrease of mean spherical candle-power with a large initial increase, is that in some cases the final mean spherical candle-power of a lamp is actually greater than its initial mean spherical candle-power.

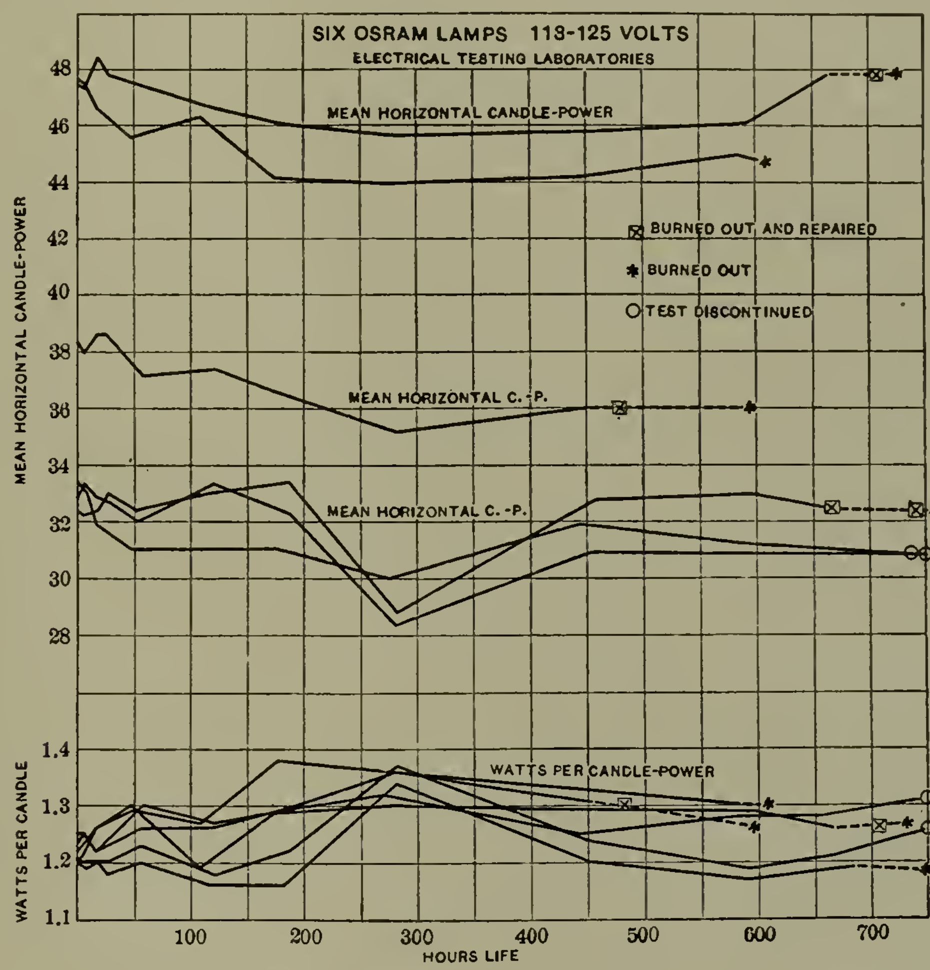


FIG. 11

For purposes of ready comparison, life curves of a representative tantalum and of a carbon lamp burned at 3.1 watts per candle are shown in Fig. 7. The candle-power of both is on a mean spherical basis. The exaggerated initial rise of the candle-power of the tantalum lamp is very apparent. Curves for watts per spherical candle-power give an opportunity for a comparison of the relative electrical economy of the two kinds of lamp.

The data on some of the makes of tungsten lamps are extremely meagre, a circumstance which in some cases is believed to correspond to a backward state of their commercial development. Fig. 8 gives the results of tests* of two Kuzel lamps of ap-

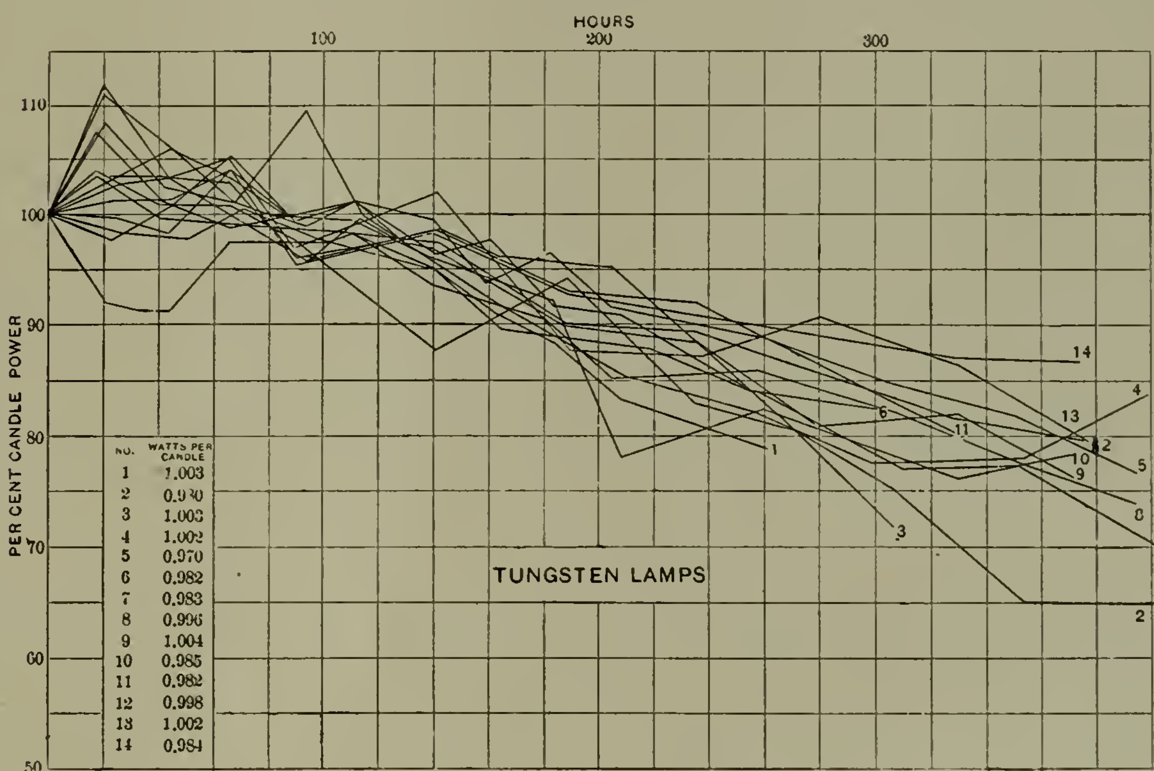


FIG. 12

* Kremenezky "Elektrotechnik und Maschinenbau," 1906, No. 6.

proximately 30 volts and 11.5 candle-power, made at the Technologisches Gewerbe-Museum, in Vienna.

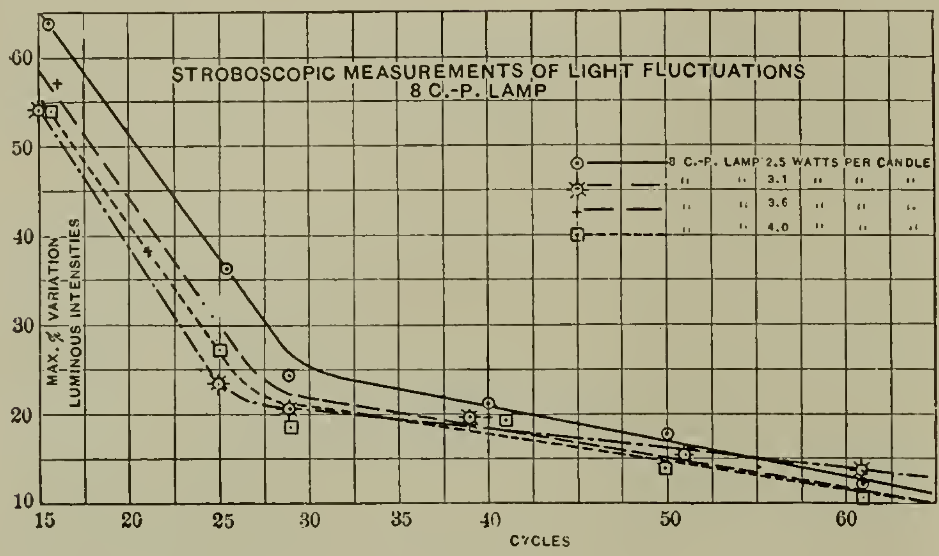


FIG. 13

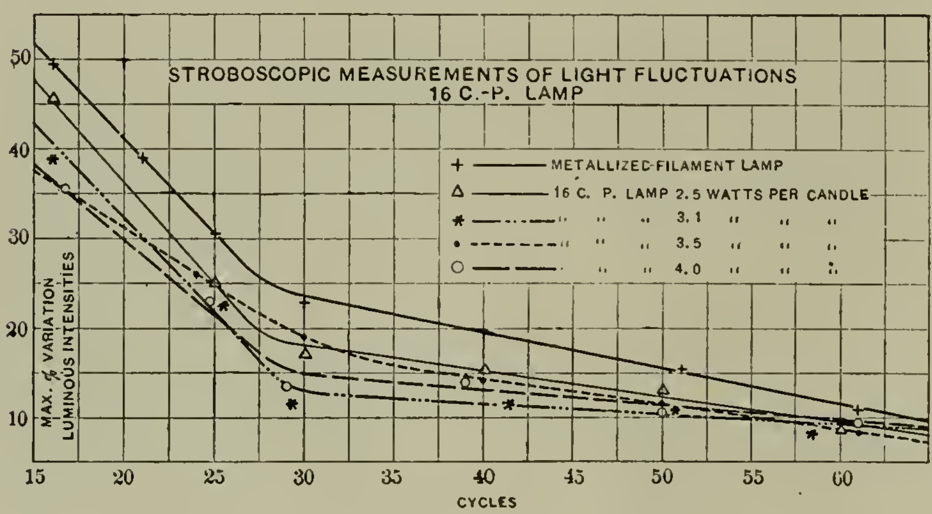


FIG. 14

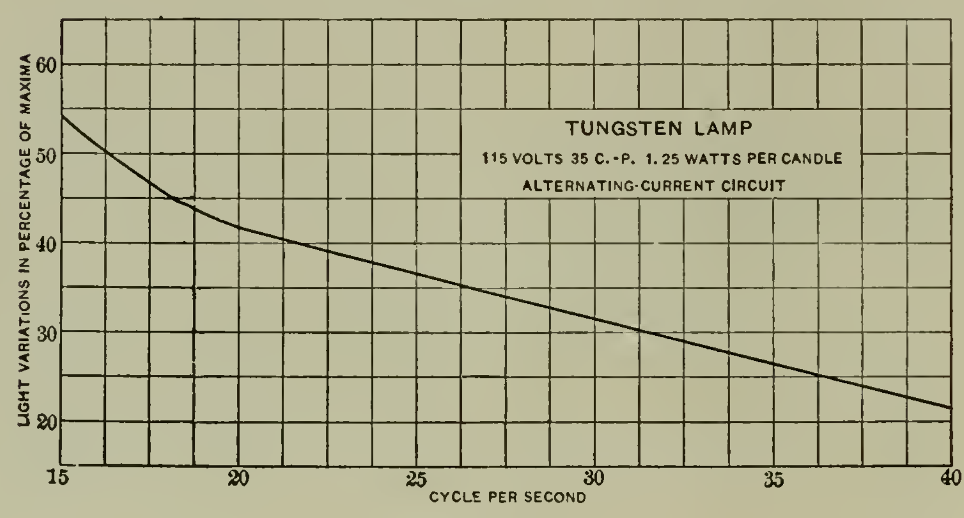


FIG. 15

These lamps consumed approximately 1.25 watts per candle initially.

One of them reached the extraordinary life of 3537 hours, with a decrease in candle-power of about 10 per cent. The filaments in both the lamps were burnt through and repaired once in the course of their life. The result of the repair was an increased candle-power, which is shown clearly on the curve.

The average result of tests of three Osmin lamps of 55 volts and 44 candle-power are shown in Fig. 9. These tests were made in the laboratory of an electrical company in Vienna. The lamps showed a life of 1200 hours and a decrease in candle-power of 14 per cent. in that time.

The results of a test of three Osmin lamps of 55 volts made at the Municipal Electricity Works, Vienna, showed an initial candle-power of 27.3 and initial watts of candle-power of 1.25. After 2239 hours of burning the candle-power was 23.4 and the watts per candle 1.45. Six 54-volt Osmin lamps tested at the Technologisches Gewerbe-Museum consumed initially 1.17 watts per candle. After 1776 hours the watts per candle were 1.24. The candle-power of these lamps is not given in the report. It should be noticed that all the above lamps are low-voltage lamps, from which a better result is to be expected than from 110-volt lamps.

The results of tests made at the Reichsanstalt of 16 Osram lamps of from 117 to 111 volts and 25 to 30 candles are shown in the curves of Fig. 10. This test extended for 1000 hours. In the course of that time 5 out of a total of 16 lamps had failed, while 11 lamps were still burning. The characteristics of the lamps seem to be a moderate initial rise in candle-power and a very slow subsequent rate of decline.

In Fig. 11 are shown the individual curves of six Osram lamps of 32, 35, and 45 candle-power, tested at the Electrical Testing Laboratories. The results of these tests differ from the results of the Reichsanstalt test in that they show practically no initial rise in candle-power. The decrease in candle-power of the lamps throughout life, however, is very slow. The watts per candle are also almost constant. The life of the lamps was, on the average, considerably shorter than the life of those tested at the Reichsanstalt.

Tungsten lamps of quite another foreign make tested at the Electrical Testing Laboratories exhibited a very large initial increase in candle-power, followed by a practically constant condition. The average life is also much shorter than in the case of the Osram lamp.

The curves of Fig. 12 are of particular interest since they show the performance of lamps made in this country. These lamps were tested at an average initial consumption of 0.99 watts per candle. Their average life was 363 hours, even at this high initial efficiency, and the average decrease in candle-power was 17.7 per cent. These curves demonstrate that incandescent lamps can be produced which will operate successfully at one watt per candle and will give a satisfactory life. The candle-power of these averaged about 40.

COLOUR OF LIGHT AND EFFICIENCY

The colour of the light from the tantalum lamp is whiter than that of the carbon lamp, and the colour of the tungsten lamp is still whiter than that of the tantalum lamp. The light of the tungsten lamp resembles quite closely that of the acetylene flame. The increased whiteness of the light, which is produced evidently largely as a temperature effect, and which does not involve a preponderance of certain colours, such as green or violet, constitutes a point of real superiority in the tungsten lamp. Time has been lacking to make a regular spectro-photometric study of these lamps. A simple experiment, however, has been made which gives some idea of the increased radiation of the shorter wave lengths, both of tungsten and tantalum lamps, as compared with the carbon lamp at 3.1 watts per candle.

The metal-filament lamps were photometered against the 3.1-carbon lamp directly and then with a red, green, and blue glass interposed between the eye and the eye-piece of the photometer. The intensities so measured, expressed in percentages of the intensities measured without coloured glasses, are given in the following table:—

TABLE V.

	Tantalum Lamp, Per Cent.	Tungsten Lamp, Per Cent.
Total light	100	100
Red light	90.5	83.0
Green light	100.3	101.8
Blue light	109.2	126.5

FLICKERING ON ALTERNATING CURRENT

It has been established as a result of practice that, in general, it is not possible to operate incandescent lamps on 25-cycle current with satisfactory results. This statement is made with a knowledge of the fact that in certain cities a large amount of lighting is actually being done on 25-cycle circuits. Yet under some circumstances 25-cycle current produces such marked flickering of incandescent lamps that its use is absolutely impossible.

It is an interesting question whether the tungsten lamp presents any advantages over the carbon lamp for use on low-efficiency circuits. Its positive temperature coefficient and the relatively low radiating power of its surface would tend to reduce the flickering, while the extreme fineness of the filaments, which results in a smaller thermal capacity, and the high thermal conductivity which, as a metal, it probably possesses, would tend to increase the flickering. A few preliminary tests have been made in an attempt to gain some information on this question. It was very quickly discovered, however, that the question is so very complicated that a considerable research will be required to ascertain definitely the facts of the case.

Eleven tungsten lamps were attached to the ceiling of a small room, producing a brilliant illumination in the room. Three observers attempted to determine the presence or absence of flickering. With the lamps at their normal voltage of 115 and with a frequency of 25.5 cycles per second, L. found the flickering marked; M. found the flickering marked; S. could see a flickering intermittently, as when his head was moved suddenly. With the same lamps, but with the voltage reduced to 100, the flickering was imperceptible to all the observers.

As the voltage was raised successively to 105 and 110 volts, the flickering became perceptible. When five of the lamps were removed, leaving only six lamps in position, it was the consensus of opinion of the three observers that the flickering was less marked than when all the lamps were in. In other words, the intensity of the sensation of flickering seems to be a function of the illumination. The flickering was imperceptible when looking directly at the lamps, but could be observed only through light which is not focussed directly on the fovea of the eye. To institute a comparison between the flickering of the tungsten lamps and of carbon-filament lamps, two procedures may be taken:—

First, take a sufficient number of carbon-filament lamps of candle-power comparable to the candle-power of the tungsten lamps, lamp for lamp.

Second, take a sufficient number of carbon-filament lamps having a filament of approximately the same diameter as the diameter of the tungsten filament.

The numbers of the carbon-filament lamps must be so chosen as to give substantially the same amount of light as the tungsten lamps. The first of the two above alternatives was chosen for a comparative test, that is, twelve 32-candle-power carbon lamps were substituted for the eleven tungsten lamps. These were operated at 3.1 watts per candle. At the same frequency as was used for the tungsten lamps, no flickering could be observed. This is not a surprising result, since the diameter of carbon filaments is much greater than the diameter of the tungsten filaments, and consequently their thermal sluggishness is a much more important factor.

In view of the very considerable advantages which would be gained if it could be shown that it is feasible to operate incandescent lamps on alternating-current circuits of frequency low enough to permit of the easy operation of synchronous converters, that is to say, a frequency of 25 cycles or slightly greater, the question of the variation of the light of incandescent lamps during a half cycle of the alternating current has also been subjected to an experimental investigation by the use of a stroboscope.

To the axis of a small synchronous motor was attached a disc with narrow radial slots cut in it, one for each pole of the motor. The lamp was placed behind this disc, while close to it and in front of the disc a suitable photometer was arranged. The motor was driven from one of two alternators, having their shafts coupled together, and the lamp was supplied from the other alternator. The phase of the current passing through the lamp with respect to the current in the motor could be shifted through known angles by shifting the armature ring of one of the coupled generators. This generator arrangement, which was planned originally chiefly for meter tests, proved itself to be extraordinarily convenient for such stroboscopic measurements as are here described.

With the use of this arrangement, curves were plotted showing the variation in the intensity of the incandescent lamps as the current through the lamp rises from zero to its maximum value and decreases to zero once more.

To discuss these results, the percentage variation of the light of the lamp per cycle was taken under all the different conditions. These percentage variations were plotted in curves shown in Figs. 13 and 14, using frequencies as abscissas. The curves so obtained, while exhibiting certain irregularities due to experimental difficulties, are fairly concordant and exhibit a common character.

The percentage variation seems from these curves to be expressible by two linear relations, with a point of sharp curvature occurring between 25 and 30 cycles per second. That is, as the frequency is increased from 15 to 25 cycles the diminution in flicker is very rapid. Above 30 cycles the diminution in flicker is very slow. Since it has been found possible in some places to operate incandescent lamps on 25 cycles, it would seem probable that a comparatively small increase in the frequency, which would carry the lamps beyond this apparently critical point in the curve, might make feasible the general operation of incandescent lamps from alternating-current power circuits.

Similar tests to the above have been carried out on a 40-watt, 35-candle-power, 115-volt Osram lamp. The results of this test as shown in Fig. 15 indicate that the stroboscopic variations of a tungsten lamp of this size are not much different from those of an ordinary lamp rated as an 8-candle-power lamp when forced to

2.5 watts per candle. The stroboscopic measurements, however, may be subject to certain of the difficulties which affect the detection of flicker by the eye. In other words, the degree of intensity of the light upon the photometer disc may have an influence on the results obtained. However, if the results of this preliminary test can be confirmed by later and more careful experiments, the tungsten lamp will be found to be less adapted to use on alternating circuits of low frequency than the standard lamp of to-day.

CONCLUSION

From the data given above it seems certain that the electric lighting industry is face to face with a change of almost revolutionary character. The standard of incandescent lighting efficiency will be brought by the tungsten lamp to a point about three times as high as it is at present. The efficiencies of all other incandescent lamps and of enclosed arc lamps are exceeded by that of the tungsten lamp. In other words, with the possible exception of some forms of vacuum-tube lighting and of the magnetite and flaming arc lamps, the tungsten lamp is the most efficient electric illuminant. Combined with its virtue of high efficiency it has the other advantages of incandescent lamps in being perfectly simple in its character and construction and in being capable of subdivision into small units.

The Trasformation of Electric Power into Light

By Charles Proteus Steinmetz

Of all the achievements of modern science or engineering the production of light is the least creditable. In the transformation of electric power into mechanical power, as in the electric motor, or the transformation of mechanical power into electric power, as in the dynamo, efficiencies far higher than 90 per cent. have been reached. Even in the steam engine or steam turbine, 60 per cent. or more of the available energy of the steam as it issues from the boiler is recovered as mechanical work.

In the production of light, the efficiency of the incandescent lamp is measured by a fraction of 1 per cent., and if we should succeed in increasing the efficiency of light production tenfold,—get ten times as much light as we get now from the same power,—the efficiency of production of light would still be ridiculously low. The main reason for this condition appears to be that in the incandescent lamp or the ordinary carbon arc lamp the light is really a by-product, that is, the lamp converts electric energy into heat, and only incidentally produces light.

LIGHTING BY INCANDESCENCE

Incandescent lighting is effected by the electric current, either by raising the temperature of the light-giving solid body, a lamp filament, by passing a current through it, or by passing the current from it into another body. In the latter case the temperature of the boiling point of the material is reached, and the crater of the carbon arc lamp is at the highest temperature that can be reached; this gives it an incandescent light of maximum efficiency, probably not very far from half a watt per candle-power. But the large amount of energy, which is conducted away by air currents, etc., greatly reduces the actual efficiency of the carbon arc below this value.

When producing light by passing an electric current through the conductor, as in the incandescent lamp, no such efficiency can be reached. Here carbon is also chiefly used. The higher the temperature of the incandescent-lamp filament, the greater is the efficiency; but the limit of the temperature is not the boiling point of carbon, 3500 degrees Cent., but far below that; it is the temperature where evaporation of the filament becomes so rapid as to limit its life below economical requirements. This is probably not very far from 1800 degrees Cent.

An incandescent carbon filament evaporates, thereby decreasing in cross-section, and increasing in resistance; the current decreases, therefore the temperature decreases, and with the temperature the efficiency decreases. As the condensed carbon vapour blackens the globe and obstructs the light, another decrease of light results from absorption. Thus efficiency has to be sacrificed in the incandescent lamp to get good life, and the specific consumption of electric power, instead of being one watt per candle-power as in the case of the arc lamp) becomes as high as four watts per candle-power.

The arc, then, is the more efficient illuminant. But its efficiency is still low, and here there has been a similar result: to increase the life, the efficiency has been decreased by enclosing the carbon arc, in the present long-burning lamp. Increasing the efficiency of the arc by reducing the conduction of heat by a decrease of the diameter of the carbon has also been tried, with the same result,—exchanging efficiency for life.

In the incandescent lamp, the problem of increasing the efficiency can be attacked in two ways. One way is to replace the carbon by a material which has a lower vapour-tension at high temperature. While carbon has the highest boiling point, it is not the boiling point which is of importance in a lamp filament, provided that this point is sufficiently high,—it is the vapour-tension far below this point.

For instance, the metals osmium, tantalum, wolfram (tungsten) have a lower melting point or boiling point than carbon, but they have at the same high temperature a lower vapour-tension. These metals can be operated at a higher temperature than carbon, and as lamp filaments they give a much greater efficiency than the carbon filament.

ELECTROLUMINESCENCE OF VAPOURS AND GASES

The problem of efficient light production consists of producing radiations; that is, vibrations of the molecules or atoms of the light-giving body, of frequencies within a limited narrow range, that of a visible radiation, and as few vibrations as possible outside of this range. When heating a solid body, the energy put into it as heat sets the molecules or atoms in motion, in vibration. But when heating a gas or vapour, the energy put into it appears not as vibration of the molecules, except perhaps indirectly at extremely high temperature, but as rectilinear motion or pressure. So heat, while making a solid or liquid incandescent, does not make a gas incandescent or luminous, but merely increases its pressure.

There are methods, however, of setting the gas molecules in vibration. By chemical reaction or electric stress gases become luminescent; that is, the molecules of the gas are set in vibration. For instance, if the gas is used as a conductor of electric current, then the molecules of the gas are set in vibration, and we find a definite period of vibration, or a number of periods or frequencies, in which the gas molecules or atoms can vibrate; that is, gases give line spectra.

So in a mercury arc, the molecules vibrate not as those of a solid body, but only with a small number of wave-lengths. Many of these are within the visible range, within the fraction of an octave which is seen by the eye: one is of a greenish-yellow; another wave is green; another is dark-green; another is blue. Two vibrations appear as violet, and numerous vibrations excited by the mercury arc are, in the ultraviolet, very short.

Here results a definite rate of vibration, practically independent of the temperature. The mercury vapour vibrates at that frequency which gives that particular yellow light, and that particular green light, etc., whether the temperature is high or low, and the wave-length does not change as it does with the radiation of a solid incandescent body; it is fixed by the nature of the molecule, so that the temperature has no direct effect.

It has an indirect effect in so far as at higher temperature periods of vibrations may become more prominent, while small, or almost non-existing, at low temperatures. For instance, in mercury vapour the lowest frequency is that giving the greenish-yellow line, but no appreciable amount of vibration is so slow as to give red light at ordinary temperature.

When the temperature is raised very high (but still below the temperature of the incandescent-lamp filament) then the mercury molecule begins to execute a slow vibration, which gives an intense red light, and red lines appear in the mercury arc; with increasing temperature it gradually changes its colour from green to white to red. Here we have a particularly interesting illustration that for luminescent vapours or gases the law of the black-body radiation does not apply. In a solid black body, with increasing temperature, the mean wave-length decreases, shorter waves appear, and the light changes from the red over yellow toward white.

Now it happens that with mercury vapour at the higher temperature, a slower vibration, or longer wave, of red light increases in intensity faster than the short vibrations, and the light changes from green to white and ultimately to reddish-pink at high temperature. It is a mere incident, but it shows that temperature has no effect directly, only indirectly, in that particular rates of vibration may appear with change of temperature, may become more or less prominent, depending on the material which luminesces.

As a rule, then, it can be said that such an arc or a luminescent gas or vapour is more efficient as a producer of light the lower the temperature. This is just the reverse of the solid incandescent body. In a gas or vapour, a certain definite vibration is impressed directly by the electric energy or the chemical energy which sets up the oscillation; the heat which is produced is incidental, is a by-product, and, therefore, a waste. The lower the temperature the less waste of energy takes place as heat, and the more efficient is the luminescent gas. This is one reason why the mercury arc is extremely efficient: it has the lowest temperature.

With mercury vapour which is set in vibration by the current, a very high percentage of the total energy is radiated in the visible range. With carbon vapour, the percentage of energy radiated in the visible range is extremely small. The carbon arc is extremely low in efficiency, practically non-luminous. Silicon also gives a practically non-luminous arc. Others, like calcium, titanium, etc., give a very high percentage of light within the visible range, and so a high efficiency of light production.

Where high economy of light production is the only, or the foremost consideration, spectra in which green or yellow preponderates are selected, such as mercury, bluish-green in the mercury arc lamp, or calcium, yellow in the flame carbon lamp. These two illuminants give high efficiency, but they give it by sacrificing the inefficient colours at the end of the visible range. But, unfortunately, the sun, as an incandescent body, gives the light of solids or liquids, and, therefore, gives all the radiations, with the red end of the spectrum specially prominent; and, since we call the sun white, the light from the mercury arc appears green, that of the flame carbon are yellow, not the yellow of the incandescent lamp, but a pronounced monochromatic hue.

The mercury arc and the flame carbon arc are useful for cheap lighting, regardless of colour. They also find an application for special effects due to their colour. So the mercury arc is eminently suited for outdoor lighting in suburban districts where its effect on foliage and snow makes it superior to illuminants containing red rays, and where the intrinsic brilliancy of illumination can be kept sufficiently low as not to show the objectionable effect of monochromatic light. The flame carbon arc finds its field in advertising, where its intense glare makes it especially suitable.

For general illumination, however, at least in this country, people have become educated to require as close an approach to daylight as possible; that is, to require white light. The problem, then, is to find a vapour which gives spectrum lines over the whole visible range, distributed approximately in the same manner as the intensity in the solar spectrum, and giving as few lines as possible outside of the visible spectrum.

VACUUM-TUBE ILLUMINATION

Conduction through vapours can be of two distinctly different characters,—spark or Geissler tube conduction and arc conduction. Vapours or gases can be divided into two classes,—conducting vapours and non-conducting vapours. The conducting vapours are all of very high resistance. Hydrogen or air may be called a conducting gas, because a current can be passed through it, especially at a moderately high vacuum, as in the Geissler tube, which is nothing more than a tube containing the gas used as a conductor, at a few millimetres pressure. At this pressure air becomes a fairly good conductor, but the resistance is very high compared with the resistance of conducting solids or liquids. The passage of current through the conducting gas of the Geissler tube produces light, by some form of luminescence.

The mechanism of this light production does not seem to be known, but the light seems to be somewhat of the character of a by-product. The Geissler tube is extremely efficient when operated with an alternating current of very high frequency. With decrease of frequency, its efficiency decreases and heat is produced; that is, the frequency of radiation from the Geissler tube seems to vary with the frequency of the impressed alternating electromotive force, and have its intensity maximum near the visible range only at very high frequency currents.

The production of light in the Geissler tube, therefore, seems to be connected in some way with the change of electric stress. It is not dependent on it, because even with a steady current the Geissler tube gives light, but its efficiency of light production vastly increases, and the energy is converted more into light and less into heat, with increasing frequency. Herein seems to lie the great difficulty in this method of producing light by using conducting gases at low pressure.

Considerable work has been done in this direction by able investigators, and with some success. The Geissler tube gives a very nice light, and by using a suitable gas it can be made to give any colour, only the intrinsic brilliancy is very low. Very large tube surfaces must, therefore, be used for illumination, of a magnitude probably a hundred times as large as with the mercury arc, which latter is already recognized as a luminous source of low intrinsic brilliancy. In the last years, even with a frequency of 60 cycles, good efficiencies seem to have been reached. The author does not believe it possible, however, to approach the magnitude of efficiency as given by the mercury, calcium, or titanium spectrum.

THE ARC

The electric arc makes its own conductor. The continuous production of the vapour-steam requires power in raising the negative material to the boiling point, evaporating it, and producing its rectilinear velocity. This power must be supplied by the electric circuit, as a potential drop at the arc terminals, independent of the length of the arc, and of the current,—if the volume of the vapour-steam is assumed as proportional to the current, which seems to be the case. This potential drop may be called the counter electromotive force of the arc.

From the character of arc-conduction,—that the current makes its own conductor,—it follows that the arc must be started; that is, the vapour-bridge which carries the current must first be produced by the expenditure of energy before the current can flow.

It also follows that the arc is a direct-current phenomenon, and, in general, cannot exist with an alternating current. With an alternating electromotive force at the end of the half-wave the current dies out, and, therefore, also the vapour-stream, and the next half-wave, to pass in opposite direction, requires a vapour-stream moving in the opposite direction. This does not exist, and the current does not pass; but the arc dies out at the end of the half-wave, except if the supply voltage is sufficiently high to jump a spark across the terminals at every half-wave, through the residual vapour left by the preceding half-wave.

An alternating arc, therefore, must be at every half-wave in the condition for starting by a spark. Stroboscopic photographs with metal arcs show this phenomenon,—a sharply defined static spark at every half-wave, gradually spreading out to the more diffuse arc-flame and then dying out at the end of the half-wave, to start again by a spark at the next half-wave.

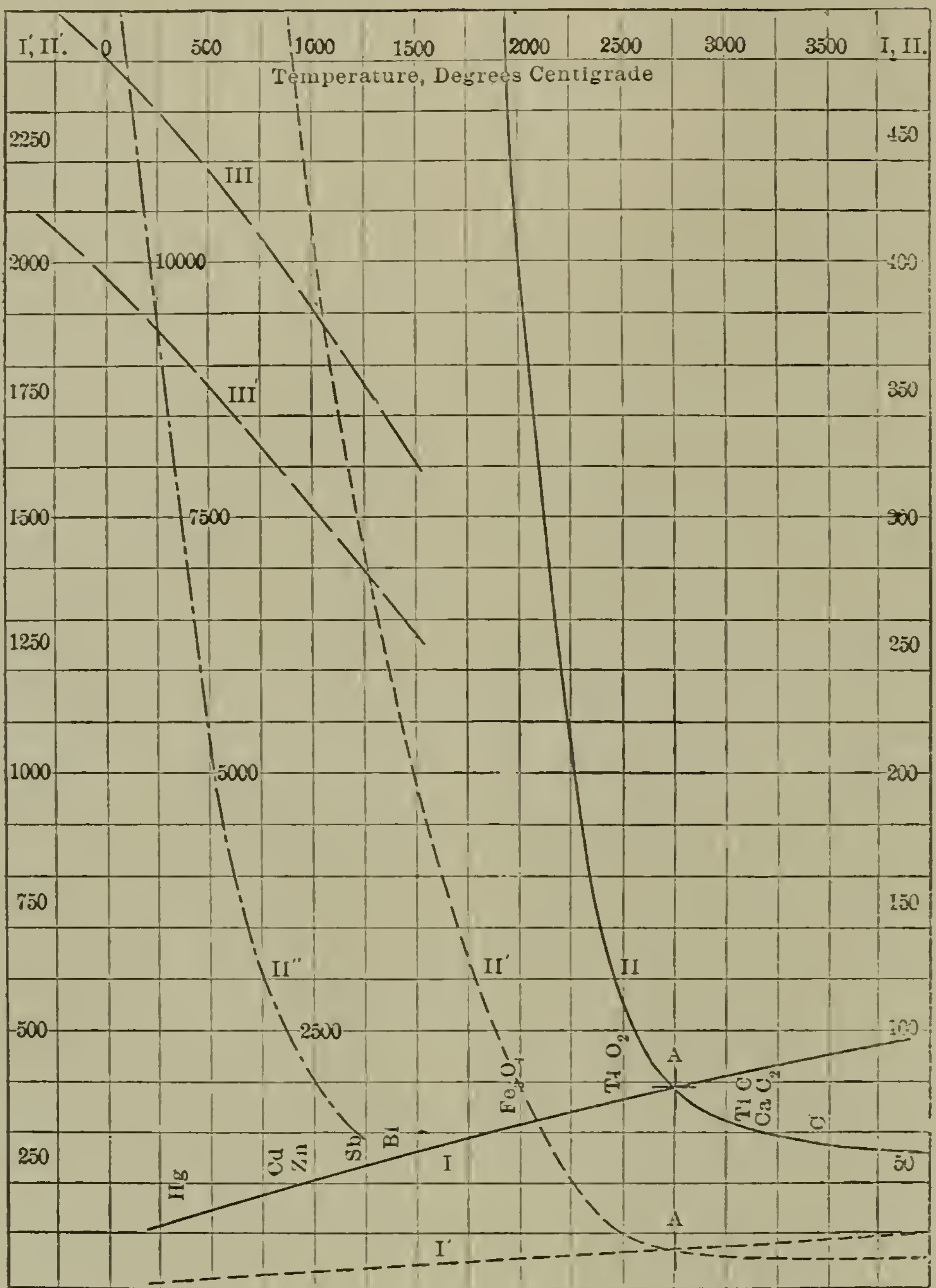


FIG. I

The voltage required to maintain the vapour-stream, or the voltage consumed by a direct-current arc, increases with increase of the arc temperature, that is, increase of the boiling point of the terminal material. It is lowest for the mercury arc, highest for the carbon arc. For a $\frac{1}{2}$-inch arc it is shown approximately by Curve I. in Fig. 1, with the temperature as abscissas.

The voltage required to jump a spark across the gap between terminals, shown roughly by Curve II. in Fig. 1,* decreases with increasing temperature, as is well known, and intersects Curve I. at some temperature, *A*, probably somewhere between 2500 degrees and 3000 degrees Cent. Above this temperature the spark-voltage is below the arc-voltage, and a voltage sufficiently high to maintain an arc is, therefore, sufficiently high to start it again at each half-wave of alternating electromotive force. That is, materials as arc terminals, which have a boiling point above the temperature of intersection *A* of Fig. 1, maintain a steady alternating-current arc at about the same voltage as a direct-current arc; while materials with a lower boiling point than *A* require a higher voltage, usually very many times higher, to maintain an alternating than a direct-current arc. It must be considered, however, that the temperature of the boiling point, while being the foremost factor, is not the only factor in determining the position of a material on Curves I. and II., Fig. 1. Individual characteristics somewhat modify the position.

Where, therefore, spark gap terminals are desired not to maintain an alternating arc, as for lightning-arrester cylinders, they are found on the lower range of the curve: mercury, cadmium, zinc, antimony, bismuth,—the so-called "non-arcing metals." Where electrodes for alternating-current arc lighting are required, they are found at the upper end, above *A*. In this range belong carbon and most carbides, as those of calcium and titanium.

Even carbon shows the phenomenon of re-starting at every half-wave by a high peak at the beginning of the electromotive force wave, as shown first by Tobey and Walbridge, in a paper on alternating-current arc waves.† With increasing approach to *A*, this peak at the beginning of

* This curve is only estimated, and so can make no claim to numerical accuracy. Curves I. and II., the arc and the spark-curve, are shown once more in 1-5 scale (left-side ordinates) in dotted lines, and the lower part of II. once more, in 1-25 scale as II'' in Fig. 1.

† Transactions A. I. E. E., 1890, vol. 7, page 367.

the electromotive force increases in height, and the power-factor of the circuit tends to decrease, by wave-shape distortion. Immediately below the intersection point *A* are found very refractory metals, as tungsten, and metaloxides, as those of titanium, etc.

The range of voltage between Curves I. and II. in Fig. 1 is the range in which rectification takes place. That is, by maintaining the vapour-stream issuing continuously from one terminal, by an outside source, or by the overlap of several arcs, the alternating electromotive force can pass a current in one direction only, and so is rectified. In this range, the arc-stream is a unidirectional conductor, of very low resistance in one direction, of practically infinite resistance in the opposite direction.

The voltage range of rectification, then, is highest at the lower end of the curve, and decreases gradually to zero at the point *A*. With the first members of the group, the upper limit of the rectification range is somewhat cut down by the disruptive strength of the air surrounding the arc-stream, being lower than that of the arc-stream, and so passing a static spark outside of the arc-stream, or, with a vacuum-tube arc, by a Geissler tube discharge through the residual gas. In the latter case the maximum voltage which can be rectified depends upon and measures the perfection of evacuation. Such Geissler tube discharge curves are sketched roughly, in dotted lines, as III., III^1, in Fig. 1.

While vapours, like mercury, zinc, etc., are very good conductors when in motion under the influence of the current, of a conductivity comparable with that of electrolytes; when not under the influence of the current they are almost perfect insulators, and so can be distinguished from the so-called "conducting gases," as hydrogen, air, etc., as "non-conducting vapours. Low-temperature metal vapours thus are non-conductors.

THE ARC AS AN ILLUMINANT

There are two distinct ways of producing luminescence of the arc: first, directly by using some material as negative which gives a luminous spectrum, that is, a spectrum with many lines in the visible range, preferably covering this whole range, to get white light; secondly, indirectly, by using some material to carry the current which gives a very high temperature to the arc-stream,—which means practically carbon,—and making the arc-stream luminous by feeding some light-giving substance into the arc from the positive terminal. In the former case the arc has the characteristic of the iron arc or titanium arc, whatever material is used; in the latter case, it has the characteristic of the carbon arc.

Since the carbon arc is the steadiest arc, the most work has been done in the latter direction. The former method, of feeding the luminescent material by the current from the negative material, has the advantage, however, that the efficiency does not depend on the temperature of the electrodes; the rate of consumption of the negative electrode can thus be greatly decreased by maintaining it at low temperature; while the positive electrode, which takes no part in the arc conduction, can be made entirely non-consuming. This method seems to be a more direct conversion of electric power into light.

These two forms of arc have come into prominence recently, the flame carbon arc and the metal compound arc, that is, an arc in which carbon is not used, but some other material which gives a luminous spectrum, as iron or titanium. In the former case the characteristics are those of the carbon arc. All the materials which can be used to increase the efficiency of the carbon arc,—calcium compounds are used almost exclusively,—deposit as solids after passing through the arc-flame, and, therefore, ventilation must be provided to carry off the smoke; that is, the arc must be a so-called "open" or "burning" arc The life of the electrodes is about ten hours. Flame carbon arcs, therefore, have short-life electrodes, though their efficiency is high.

Again, efficiency has to be balanced against life, or decreased cost of power against increased cost of electrodes and attendance. Here in the United States the short-burning arcs for street lighting have practically disappeared. Indoors the excessive brilliancy and the smoke are objectionable, so that the flame carbon arc does not offer much prospect for general illumination.

More prospect of success appears to exist in the true luminous arc, an arc using as negative a material giving an efficient and brilliant spectrum. Such material should give lines uniformly distributed not only in the green or yellow, but over the whole visible range, and the material should not be attacked in air, even at high temperature. The arc must be an open arc, since the material deposits as solid, and to get electrodes with long life, a material is required which is stable at high temperature in the air.

There are very many metals which give luminous spectra, but those which give white are substantially the metals of the iron group only,—iron, titanium, wolfram, etc.

Long-burning quality requires a material which is not affected, or only little affected, by the air. This, in general, excludes the metals, but requires a stable oxide or other fairly stable compound, as some carbides are. It should also be a conductor, since as arc electrode it has to carry the current. In the intermediate oxide of iron magnetite (Fe_3O_4), a material is found which is a good conductor, is stable at high temperatures as well as at low temperatures, and gives a white spectrum. In such an electro luminescent arc, any stable material is suitable as a positive terminal.

Copper is generally used because it is cheap, is stable at fairly high temperature, is a very good conductor of heat, and when heated by the arc carries the heat away with sufficient rapidity not to melt or oxidize appreciably. In all these arcs the vapour stream from the negative is a necessity. In the mercury arc it is easiest of observation, because the arc is enclosed in a glass tube.

The amount of vapour produced by the current from the negative is usually many times greater than necessary to carry the current, and most of it can be condensed without any appreciable change in the arc-stream. So also magnetite consumes at a much greater rate than is necessary, of an order of $\frac{1}{4}$ gram per ampere-hour. This rate of evaporation is greatly reduced by the addition of small quantities of a material which is chemically not much different from magnetite, but is much more refractory; so that at the temperature where the magnetite melts this material is still solid and forms a kind of sponge in which the melted magnetite is held and its consumption greatly retarded.

Magnetite, however, while a good conductor of the arc-stream, is not very efficient as a producer of light, and added thereto are other materials which give a very high efficiency, as titanium compounds.

In the magnetite arc as used at present, that is, in which the magnetite electrode contains titanium oxide, etc., magnetite is essentiallly the carrier of the arc conduction, just as carbon is in the yellow-flame arc; titanium, with its highly efficient white spectrum, takes in the magnetite arc the same place as calcium in the flame arc, as light-giving substance, but titanium is carried into the arc stream by the current from the negative, while calcium in the flame arc enters by evaporation from the positive.

The elimination of carbon in the magnetite arc excludes combustion, and this increases the life of electrodes to about twenty times that of carbon electrodes under the same conditions; but just as with the carbon arc, the efficiency of the magnetite arc can be varied over a wide range, with a corresponding variation of life in opposite direction. That is, by sacrificing some efficiency the life can be greatly increased, or the efficiency can be increased by somewhat reducing the life, by increasing the percentage of light-giving material, usually titanium oxide in the magnetite arc, calcium fluoride or borate in the flame carbon arc.

In either case, a very high percentage of the light-giving material tends to the formation of a non-conducting slag at the electrode surface, and if the highest possible efficiencies are desired,—¼ watt per candle-power, and better,—the effect of the non-conducting, or poorly conducting electrode surface has to be eliminated, by starting the arc from the side of the electrode, or some other method.

Magnetite, titanium oxide, and most metals or their compounds are below the intersection point *A* in Fig. 1; that is, do not maintain a steady alternating arc. For alternating arcs, therefore, one of the materials is required which is above point *A*. In this range there are carbon, carbides, and similar compounds.

Thus the titanium arc with alternating current cannot use magnetite as carrier and titanium oxide as light-giving material; but titanium carbide is used as arc conductor. It obviously is not so incombustible as the oxide, but still so much more stable than carbon as to be well within the range of long-burning arcs.

To conclude, then, in the luminous arc we seem to have the first instance of a commercial application of a direct conversion of electric power into light, without heat as intermediary form of energy. It is not limited to very low values of efficiency; but, so far, it seems that only the green mercury spectrum, the yellow calcium spectrum, and the white titanium spectrum offer an efficiency so vastly superior to that of incandescent solids that as regards the efficiency of light production no possible improvement in incandescent lighting could hope to approach it. Typical of these three most efficient spectra are the mercury-arc lamp, of practically infinite life and bluish-green colour of light; the yellow flame carbon arc of the short life of the open arc-lamp of old, and the white titanium carbide or magnetite arc, of a life equal to or greater than that of the enclosed carbon arc.

DISCUSSION

Prof. H. C. Parker, of Columbia University, in opening the discussion, said that it is not the melting point of refractory substances that gives a high efficiency, but it is the other point of disintegration or vaporization, as is beautifully shown by the tungsten filament and the tantalum filament, as was pointed out. These metals have a much lower melting point than carbon, and yet a much better vaporization, and hence show a great increase in efficiency.

A certain filament with which he had been experimenting, the substance of which is supposed to have a melting point of 1800 degrees, has shown an efficiency in experimental lamps of about 1 watt per candle, with an average life of 700 to 1200 hours. The vapour tension of this substance is remarkable; that is, it is almost impossible to vapourize the substance, which fact bears out the statement of Dr. Steinmetz.

One thing which had impressed J. S. Howell was the fact that practically all the efficient illuminants mentioned originated in either Austria or Germany, although in the United States we have taken these things up and surpassed the originators, possibly, in the use of the lamps.

The tungsten filament, from the nature of the material, could be most easily made in rather large candle-powers. Dr. Sharp put 25 candle-power as the lower limit, but the really practicable lower limit is higher than that; and, speaking for the General Electric Company, the speaker thought 40 candle-power would be about the lower limit at 110 volts, but lower candle-powers will be manufactured for smaller units, and lower voltage lamps will have to be employed either in series or in other ways. But while that is the limit, it fits in exactly in the place where the carbon filament is weak. The carbon filament is weak above 40 candle-power, and the tungsten filament is strong.

The tungsten filament from 40 to 200 candle-power is at its best, and at these candle-powers 200 for the incandescent lamp, with its distribution and stability, is better than twice that candle-power or more from an arc lamp. He looked to the tungsten lamp to be the competitor of the small arc lamps, and the large ones, too, for that matter, and for other forms of light, the values of which lie between 50 and 200 candle-power.

The theoretical considerations governing the absolute, what you might call the physical efficiency of the different methods of producing light, said Percy H. Thomas, had been pretty well covered.

These are very important, but they must be taken in the light of other more practical considerations before they are usable in commercial service. For instance, there are other things besides the ultimate efficiency which determine the usefulness of a type of lamp, as the conduction or convection of heat due to the presence of air.

The figures given by Dr. Steinmetz for the maximum possible efficiency of bodies were calculated, the speaker believed, on the basis only of the rated energy. If these sources are in the presence of air or other gases, there will be a conduction or convection, mostly convection, of heat, producing the lights in addition. As between an incandescent filament and an arc lamp this consideration is of great importance; the filament being in a vacuum does not lose energy by convection or conduction. This gives it a great advantage. The arc light does lose a great deal in that manner, so that its intrinsically high efficiency due to its higher temperature is not so great as might be supposed.

The size of units is of great importance. A light which has for its smallest unit 2000 or 3000 candle-power, like some of the flaming arcs, cannot get the advantage of its high efficiency, because we cannot distribute the light; in one place there is a tremendous quantity, and in another place there is very little. Not only does it leave the space between the lights dark, but it gets on the pupil of the eye, tending to contract it, so that there is less available light than if the illumination were uniform at a lower figure. That is a matter of great importance which is not fully recognized. That is the great disadvantage of the arc light, especially the open-arc light and the flaming arcs of high candle-power, and the calcium light; the eye cannot utilize the light on account of the flare which is always directly or indirectly in the eye.

Another great advantage that may be obtained by one light over another is in the intrinsic brilliancy. That is a point somewhat related to the other. The arc light is the worst, the incandescent gas perhaps less, and then we get to the tube lights, the Cooper-Hewitt light or the Moore tube. These have a very great advantage from this standpoint, and also the advantage in the elimination of shadows and that sort of thing.

The question of mere efficiency by itself, said J. W. Lieb, does not represent necessarily an advance, if it is obtained at too great a cost or the sacrifice of the life of the filaments, or if the development is obtained at too high an initial cost in the production of the filaments themselves. If in the new developments the efficiencies of 1¼ watts per candle-power for the tungsten filament were to be obtained at an important sacrifice of life, then, though the cost of production of the lamps was very low indeed, we would at once stumble on a very serious commercial handicap for such lamps. It is a fact that if we should have lamps, even though they cost but little and the cost of renewal would be low, a short life of 100 or 150 hours would make the lamps commercially impracticable, because of the fact that the continued renewal and burning out of the lamps would be a matter of very serious inconvenience. With the lamps which have been developed with the high efficiency, we have very fortunately coupled therewith a very satisfactory light.

Unquestionably, as appears from a superficial inspection of the lamps, it is necessary, without question, to look forward for a time at least to a considerably increased cost, but with such enormous saving in the amount of energy, the initial cost of the lamp becomes a factor which can well be borne.

Dr. Sharp referred to one matter which was of great interest, and in the solution of which Mr. Lieb hoped the result might have been in a different direction,—in regard to the performance of a high-efficiency tungsten lamp on 25 cycles. With the carbon filament lamps which we have now of the 3.1-watt-per-candle-power efficiency, it is unquestionably true that for the very highest standard of illumination the performance of these lamps of 16 candle-power at 25 cycles is not completely satisfactory; some might say it is not at all satisfactory. As to just where the line can be drawn, it is a matter of individual opinion, and is also somewhat of a physiological question; but it is undoubtedly true as an engineering proposition that if it were practicable to have our most efficient illuminants so that they could be used on 25 cycles with entire satisfaction, we would have a condition of affairs which would lead to some rapid and important changes in our methods of distribution. Our central power stations are very largely at present producing 25-cycle current, and at least for the illumination of the very highest standard it is hardly available with our present type of incandescent lamps.

It was hoped that the characteistics of the tungsten filament, its hanging on to the candle-power, even with large changes of voltage, presented some hope that the tungsten filament might be the long desired one which would fill these requirements. But it seems to be a race between this physical characteristic and the other one of the extreme tenuity of the filament making the lamp, on the other hand, more sensitive to fluctuations of current. We, therefore, at least as far as the experiments to which Dr. Sharp has referred, still have to look forward to some further developments, some further modification, which may solve this problem.

This question of the efficiency of incandescent lamps and their performance is of the utmost importance to the lighting industry, as is shown by the difference which a question of pure policy in the handling of the illuminants is apt to produce. In England and on the Continent it is the practice of electricity supply companies not to furnish incandescent lamps with a current. The foreign municipalities in granting privileges to the local companies thought it wise and best to protect the public against possible abuse by avoiding a requirement that the company should supply incandescent lamps within and included in the cost of current supply. The result is that there the public goes out into the open market for the purchase of its incandescent lamps.

What the result of that line of policy has been, was made quite evident recently by the results of some tests made in England, particularly of the incandescent lamps which were found on customers' circuits after a number of years of such operation. The lamps were found to be of all types and all efficiencies, particularly of the lower kind, so that the efficiencies of the lamps found on the system ranged all the way from 6 watts per candle-power to 8, 9 and 10 watts. This has attracted the attention of engineers abroad to this problem, and there is a growing feeling now to deviate from that practice and introduce a different line of policy so as to maintain a high standard of illumination, because in the purchase of illuminants like incandescent lamps it is not the same as buying a candle at the grocery store; it is a difficult article to purchase at best, and the public is too prone, in the purchase of incandescent lamps, to look entirely on the question of their life, the result being an enormous sacrifice of their efficiency. In these new illuminants we have those which will keep up their candle-power in the most remakable manner, far beyond anything we have had here before, and with a life that seems to satisfy every requirement.

W. G. Clark said that in the matter of the evaporation of carbon at the temperature of the incandescent filament, his observations had led him to believe that the ordinary filament is not of even temperature, but is made up of very narrow zones or spots of high incandescence, and, possibly in an unflashed filament, of actual arcing in some places, and that the temperature which we observe in the mean of a series of high temperature and low temperature spots these would of necessity be very narrow, but from the fact that the filament is originally made up from a material which must pass off as a gas during the process of carbonizing, it must leave the filament somewhat porous. As the surface is carbonized before the interior, the gases leaving the interior would break through any surface seal formed by the carbonizing of the surface and reduce the cross-section of the filament at that point.

In an unflashed filament there would be a tendency to form a small arc across the gap in shunt with the continuous portion of the filament back of it. In flashing, these spots would be the first to be covered with the dense low-resistance carbon deposited out of the hydrocarbon, and as the temperature is excessively high at this point and the carbon deposited is of very low resistance, compared with the porous unflashed portion, the tendency is to over-deposit, for the carbon is not only deposited at the actual point of the greatest temperature, but for some distance on either side. Hence, while flashing improves the filament, it does not entirely eliminate the high and low-temperature conditions. But the temperature of a carbon filament probably represents the mean of a great number of extremes of temperature, and the carbon is vaporized from the high-temperature points where the greatest amount of vaporization has taken place; with the graphitized or metallized filament, the conductivity is more nearly uniform on account of the greater per cent. of dense carbon, so it is possible to operate the filament at a higher temperature.

Mr. Clark was of the opinion that the hot point condition also holds where metallic filaments are made up of tungsten filament, for the current passing through the filament at the time the centering together takes place will follow the path of lowest resistance where the arcing between the particles welds them together and particles not directly in the path of the current may not become an active part of the filament. The arcing between the particles would continue until the points of contact fuse together, when the temperature will immediately drop below the fusing point; but the points of contact would still represent the points of greatest temperature.

On account of the fineness of the particles in the Kuzel filament these zones of maximum and minimum temperature would be very close together, but this condition may account for the high resistance and high temperature coefficient of this type of filament. It has been noted that some metallic filaments which are white in colour at low temperatures still radiate as black bodies. The speaker had noted that a great many white metals turn black before they begin to radiate light. Steel of a light gray or silvery colour confined in a vacuum freed of oxygen passed through several changes in colour to black before it began to radiate light at the red end of the spectrum; this was also true of platinum, iridium and copper, but did not appear to be true of aluminum.

The desirability of securing a light which covers the entire range of visible wave length was brought out very well in Dr. Steinmetz's paper, but instead of endeavouring to secure this entire range in one material or in two similar materials, as in the magnetite titanium arc, may we not secure an efficient result by combining materials which show high efficiency at each end of the visible spectrum? As an instance, if we were able to combine the mercury vapour arc with a light from a material which showed its highest efficiency in the red end of the spectrum, the resultant light should be both satisfactory and economical.

The carbon filament is, of course, not sufficiently efficient when maintained at the temperature where the red rays predominate, but a combination of the Geissler tube effect with the mercury-vapour arc would be a step in this direction.

Regarding the tarnishing of iron in a vacuum, Dr. Steinmetz said he had observed the same thing when trying to use iron in the mercury arc. Even in a very high vacuum, iron, when heated, will show different colours. He had found also in a very high vacuum that if the mercury arc were started and the space heated from the inside, it was remarkable what a mass of gas would come from the glass balls. To get a perfect vacuum it was necessary not only to get a very high-grade mercury pump, but to have all glass connections between the mercury pump and the vacuum tube, to heat the temperature just below where they suck in and keep it at that temperature for hours, and an almost perfect vacuum will be had,—usually, but not always. His idea of the vacuum was entirely changed.

In regard to the melting point of tungsten, 3200 degrees Cent., he would not count on that value, because it is a black-body temperature of tungsten. It is that temperature at which tungsten would melt if its radiation were that of the black body. If it is not the radiation of a black body, it would not melt at that temperature, but some lower temperature. The paper expressly states that it is the black-body temperature of tungsten, but it is probably not the actual temperature.

Many things which are now interesting us have been tried before. An exhausted glass tube, a Crooke's tube coated inside with tungsten, and exposed to a cathode discharge, gives a beautiful white globe. The only trouble is that the luminescence excited by the cathode ray is caused by an extremely high velocity bombardment, and the impact of this extremely high velocity does not give us light only, but also gives mechanical fracture and destruction, and such a lamp has a limited life. The general difficulty in the use of this cathode bombardment is that the action goes further than merely striking the light wave,—it goes into mechanical construction, and, therefore, the life of such things is very low.

As to the discussion of the various illuminants, we are in a very remarkable situation. Only a very few years ago we had the incandescent lamp, which, as it was commonly used for series lighting in streets and in the house, was really some kind of an incandescent hairpin, which could be seen; it was like a beacon light on the river to steer by; one could see the light, but could not see anything but the light.

Then we had the arc lamp, a big blotch of light, and when under it one did not see anything, but it blinded, and before coming under it one could not see beyond it, and after leaving the light one could not see anything at all. Now the incandescent lamp has been redeemed. It has an efficiency of one watt per candle-power, which means it has superseded the ordinary carbon arc lamp.

The maximum efficiency of light given by a tungsten filament at the temperature of self-destruction is something like 0.2 of a watt per candle-power. If a tungsten lamp is run up, the efficiency goes up to something like 0.2 of one watt per candle-power, and then the filament melts; that is the efficiency at the melting point of tungsten. That efficiency was obtained long ago by the flaming carbon lamps. The yellow calcium arc has reached a high efficiency, but, at the same time, the arc is a larger sized illuminant. The incandescent lamp has the better advantage of giving better distribution of light by smaller units; at the same time, the tungsten filament does not have this advantage as much as the carbon filament, because, at least at the voltage of 110, it cannot be brought down to such small units as the incandescent lamp. Hence we have the means at hand of reaching these very high efficiencies undreamed of a few years ago, and the race is on between the arc and the incandescent.

There are some future developments possible in the increased efficiency of the arc lamp, because even an efficiency of one-quarter of a watt per candle-power is a ridiculously low efficiency from the point of view of the efficiency of the electric motor. Possibly a still yet higher efficiency than this can be had. However, we must see that what we want is not life, but illumination, and then the question of the distribution of light comes in, and depends not only on the total volume of light obtained, but also on the size of the units, and the smaller units give an advantage.

Again, high intrinsic brilliancy gives a disadvantage and low intrinsic brilliancy, that is, larger light from a given source gives an advantage. In that respect the advantage is with the mercury arc and the vacuum tube, which reduce the intrinsic brilliancy, and is against the ordinary arc and the high-efficiency incandescent lamp. Furthermore, the total illumination required also comes in as an essential factor, and that is a feature which has never had to be considered before, because until the last few years all artificial illuminants had the same colour, varying in gradation from an orange red to yellow and yellowish white, but with a different luminescent material. We have, then, the bluish green of the mercury, the monochromatic yellow of the calcium spectrum, and the white of the tantalum.

In the question of illumination comes in the difference of the physiological effect of different colours. The speaker's paper stated, for instance, that green is a much more efficient colour than red, and that the same amount of energy put in a green light gives many more candle-power than a red light. A quarter of a mile away the orange red has long ago sunk down in the darkness, while the green light still sends out a visible beam. Where a low intrinsic brilliancy is desirable is in suburban lighting; there the green, irrespective of the physical efficiency, has great advantage over the reddish yellow.

The reverse applies with very high intensity, that is, glaring light. When the light is used to draw attention for advertising purposes, the reddish yellow is always preferred, and is also more pronounced, more glaring than the greenish light. With lights of different colours the physiological effects will enter into the question of the relative value of the lights dependent on the different intensity of illumination desired. Irrespective of the absolute efficiency, the electrical and mechanical efficiency, we may find for certain classes of work that the mercury lamp is more efficient physiologically than any other illuminant, while for other classes of work the flaming carbon arc will hold its field, due to its yellow colour. In another case the tungsten lamp will be superior, but one cannot speak of absolute relative efficiency, because the physiological effect varies with the colour and intensity of the ilumination.

The Organization and Conduct of a New-Business Department

By CHARLES NATHAN JACKSON

A Paper Receiving Honourable Mention in the Co-operative Electrical Development Association's Competition

I HAVE always lived in the small city of "C.," a town of about 30,000 inhabitants, in Central Ohio. I had been in the banking business for several years, and was interested, to a certain extent, in our local electric light plant. In the course of time, however, I purchased the entire property. The former officers of the company had always been satisfied to let well enough alone, and, as the plant was paying a small dividend, they were not very aggressive. I determined to see if, by increasing the business, I could increase the net earnings of the property.

We had a total generating capacity of 600 KW., and did not do the municipal lighting. The revenue was about $30,000 per year, and the plant was loaded to its utmost capacity about five o'clock in the December afternoons. The manager in charge was a very capable operating man, and had had several years of experience at operating plants. He was drawing a salary of $2000 per year, but did not seem to know much about hustling the business. When I asked him what we had better do to increase the revenue, he said, "Hire a solicitor and install more machinery."

We finally secured a young man who had sold electricity in another town, and started him to work, and then began to make plans for increasing the capacity of the plant. We were charging ten cents per kilowatt-hour, and the young man had not been at work very long before he secured a contract for a wholesale house that would use about twenty-five arc lamps. He also got contracts for several factories, and I began to think that there was a good prospect of his building up quite a business. However, I did not see any increase in the receipts, but the manager told me to wait until next winter and all these new customers would then be using the light. Of course, we could not expect much in the summer, as they did not need it.

Gas was selling at a dollar a thousand cubic feet, and a walk through the business district at night showed all the saloons, drug stores, restaurants and hotels using gas. Upon inquiry, I found that the price of electric light to such consumers was about three times the cost of gas, and, of course, they could not afford to pay the difference. The solicitor's business soon began to drop off, and in a few months his orders were very few and far between. He merely said that he had secured every customer that he could, and could not possibly get any more.

In other cities I had seen the electric light company light all the saloons, drug stores, etc., and wondered why we could not do it. So I began to look around and see if I could not find a man who could get the business.

One day, in answer to one of my letters, Mr. Johnson, a man of about thirty-five years, called to see me, and in answer to my question as to what he could do, he replied that he did not know, but that if I would give him a guide and a right to ask a few questions, he could soon tell me. I did so, and the next day he returned and said, "I find that you have loaded your plant down with 'short burners.' About the only revenue you get is on the peak in the winter. You asked me how I could increase your net profits, and I will say that I can increase your net profits from twenty to thirty thousand dollars per year, and you need not purchase any more machinery."

I replied that I did not see how that was possible, as we could not raise our prices. He said that he would *cut* them to some customers and *raise* undesirable ones. "For example, you have a commercial light and power load of 600 KW. on the peak, or a revenue of $50 per year per kilowatt demanded on the peak. Now, there are a great many concerns, such as saloons, drug stores, restaurants, hotels and other 'long burners' that you ask to pay at your present ten-cent rate, $200 per year per kilowatt demanded, which is much too high. Imagine a drug store having forty 16-candle-power lamps, paying you $400 per year. Their gas bills are not over $150 per year, but you will let a wholesale store that closes at 5.30 burn forty 16-candle-power lamps and pay you only $50 per year, and they cost you nearly as much as the drug store.

"All of your fixed expenses are the same for both, but the drug store uses about 4000 KW.-hours and the wholesale store 500 KW.-hours. As your coal bill is not over one-half cent per kilowatt-hour, you can see the drug store would cost for coal $20, the wholesale house $2.50. So you are either making a very large profit on one or losing a lot on the other."

I could readily see that this argument was correct, and asked him how he would go about it to produce results. He replied that the town was not large enough for him to spend his entire time with us, but that he had in training several bright salesmen, any one of whom was capable of going into the town and working up the business under his supervision. Of course, it would oftentimes be necessary for him to help the solicitor on some big contract, and that he would charge me $1800 per year for the services of the solicitor, and for his own services he would ask 25 per cent. of the increased profits during the first two years; after that he would probably not be needed, as things would be running so nicely that the solicitor would be able to go it alone.

His desire to back up his ability with such a proposition made me feel safe in accepting it at once. He at once came on the ground to give us a start, and first got a friend of our company to agitate a rate ordinance, which was passed. It prohibited a charge in excess of fifty cents per month per 16-candle-power lamp to customers using light not over ten hours per day.

The "long burners," of course, were pleased and boosted it along. The "short burners," never dreaming that it would affect them, said nothing. He then sent for the solicitor, who was instructed to charge a flat rate of $5 per month per kilowatt demanded, and an extra charge of two cents per kilowatt to all light customers, except residences, who were to pay ten cents per kilowatt-hour, $1 minimum. Lodge rooms, churches and hotels were to receive a special rate.

The solicitor had no trouble in securing contracts with all the "long burners," and at the same time kept an eye open for unprofitable "short burners" and raised their price to the new rate. The wholesale house, when asked to pay $10 per month, plus two cents per kilowatt-hour, threw up their hands in horror and said that they would not stand for any such "hold-up," so they put in gas.

In October the load curve of the station looked like the solid line in Fig. 1. The load curve before looked like the dotted line. Mr. Johnson said: "You will notice that the load drops off a little after six. If we don't do something we will have a curve like Fig. 2 in December. You will notice that it will begin to drop off at 5 P. M. I am going to start a strong campaign on residence lighting, churches and lodge rooms, which commence to burn at five o'clock and get heavier as the other load goes off."

He engaged two bright young fellows and started them after residence contracts at the old price of ten cents per kilowatt-hour. They would

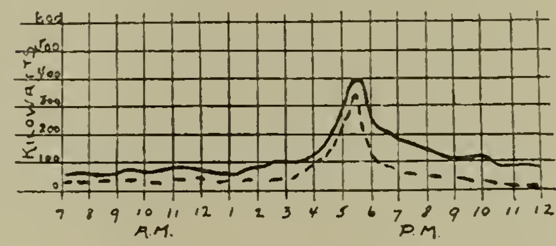


FIG. 1

turn the names of all prospective customers over to a stenographer, who would mail them a series of letters and advertising matter on electricity for home use. In that manner they would get from two to four contracts per day. All that time the solicitor was getting all the churches and lodge-rooms he could, at a six-cent rate. It was not long before I could see a change in the load curve. It began to fill out after six, and by Christmas it looked like the solid line in Fig. 3.

Johnson was not satisfied with that, but said he wanted one to look like the dotted line, and that he would get it with power business. I replied that factories did not stop work until 5.30, so their load would be on the peak. He said that large factories are on the peak, but small shops are not. He had studied their load and found that a load curve from a power circuit handling a great many large and small cus-

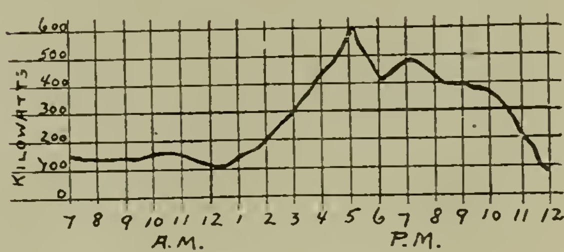


FIG. 2

tomers showed a load curve during December that began to drop off at four o'clock and reached zero at six, and at five o'clock it was only 50 per cent. of the total load. There were several large factories which he knew were on at five o'clock, consequently it must have been the small shops that began to quit at four o'clock and were practically all through at five.

He began to push power business at three cents to large and small customers alike. As there was no firm in town that handled motors, we sold them to our customers at cost. Such a low price on power secured a great many small power customers and a few large ones. He was gradually filling up the "valley" in the load curve, and our receipts in March were $5000, which made me feel pretty good.

About that time a big cold storage plant was being built, and Johnson went after the business, quoting a two-cent rate. He told me that they would require 100 H. P. about 600 hours per year, which, at two cents per kilowatt-hour, would give us a revenue of $9000, of which about 75 per cent. was clear profit. I had so much confidence in Johnson that I knew he was right, but I had to ask how the profit could be so much and how he could carry the increased load. "Nothing easier," he said. "They agree *not* to use power after 4 P. M. in November, December and January, so the only time they come near our full load is Saturday night in the summer time, and then our load is never more than 400 KW.

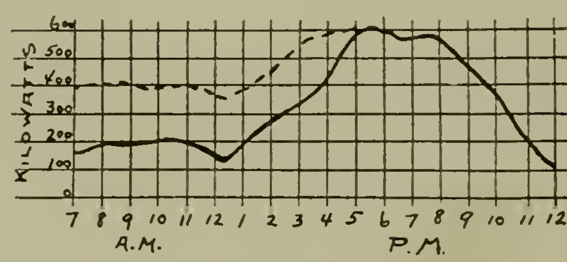


FIG. 3

"Regarding the 75 per cent. net profit, I am going to let you answer that. Do you have to put in any more machinery to carry the load?" I replied "No." "Do you require any more men to run your plant?" I said "No." "Then isn't coal the only added expense, and does it cost you over one-half cent per kilowatt-hour?" I took off my hat to him. I could see his 75 per cent. profit.

When summer came our receipts held up to about $4000 per month. All the stores were paying their "flat rate." The power customers were paying more than they did in the winter, the refrigerating plant was paying us nearly a thousand dollars per month, and I began to see visions of a good paying property.

Johnson had an office system that was very thorough and yet very simple. He first bought one section (two drawers) of a vertical filing cabinet. The folders were numbered from "one" up. He had another drawer in which he kept his 3 × 5 index cards. When a new contract came in, a work order was issued in quadruplicate, two heavy copies and two tissues: one tissue was put in the customer's folder, and the two heavy copies and the other tissue went to the operating manager, who kept the tissue and passed the two heavy copies to the line foreman and the meter foreman.

The operating manager's tissue was kept on his desk, so that he could see what orders were in the hands of the men. When the men returned their copies marked "completed" he destroyed his tissue and passed the order back to Johnson, who passed them, with the contract, to the bookkeeper, who would enter customer's name and rate on the ledger, and then would pass them back to Johnson, who filed them in the customer's folder. He issued work orders for meter tests, complaints on service, etc., to the operating department in the same way, always filing his tissues at once, so, at any time, a glance in the folder would tell what the last move was.

All prospective customers had a folder. After a visit, where anything of importance was said or done, he would dictate a "report" and file it. He also had a small deck tray, which he called the "tickler." One set of guides were for the twelve months, and one set for thirty-one days.

I have seen him dictate a report on a prospective customer, saying that if Jones & Co. renewed their lease December 1 they would be glad to accept our proposition of April 15. He would then drop a 3 × 5 tickler card in the tickler, for about December 1, calling attention to report of April 15 on Jones & Co.

One day I asked him how a certain big power deal was progressing. He looked in the folder and found that the last thing done was a letter confirming a verbal quotation. It was signed by the solicitor, and we, to test the solicitor's system, looked in the tickler to see if he was taking care of it. We found a tickler dated eight days from the date on the letter, asking if the Iron Works had answered May 7.

He taught his solicitors never to use their memory, but to keep the system in first-class shape. He said that a good man could solicit at one time fifty large deals, whose business would run from three thousand to twenty thousand dollars per year, and could tell any detail of any one of them in a very few minutes. After a call on a prospective customer, he should decide when he would call again, take his notes and then forget that such a deal is on.

There were about fifteen deals to which he gave his personal attention in our town. I have seen him come into the office after a week's absence, look at a small memo. book and say, "I must see Brown & Co. this trip." I would ask him "How about the others?" He knew no "others." He only knew those turned up for that trip, and under no circumstances would he go near any other deal.

He trained his men *never* to say anything while on a deal until they got all the information they could, then to go away and "form a plan of campaign," and when they got a plan that looked good to them, "go ahead and work it."

At the end of the second year the results showed that our revenue was $62,000 per year, and about the only increase in operating expenses was for coal. I was very glad to pay him according to our agreement, and insisted on retaining him at a salary of $1200 per year in an advisory capacity only.

Our two largest hotels looked as dark and gloomy as they could, and the owners would not install any more lamps. The solicitor, by making a special rate for a few months, lighted one hotel until it made the other look like a dungeon. That made the owner of the "dungeon" sit up and take notice. As soon as the dungeon was well lighted and a contract was secured, the solicitor had no trouble in securing a contract with the other.

We made a special rate of three cents per kilowatt-hour, with a minimum of five cents per month per 2-candle-power lamp, on signs, the customers agreeing not to light them before 5.30. As they came on after our five o'clock peak, our cost was only one-half cent per kilowatt. As the sign load would give us a revenue of nearly $60 per year per kilowatt, we considered it the best kind of business. Johnson showed me that if we charged six cents for sign lighting, we would, as a rule, not get over $60 per kilowatt per year, as they would light them at 4.30 during the holidays, and be on our peak, there would be no profit to speak of, while at the three-cent rate with the 5.30 start, it was nearly all profit.

The gas company, seeing their "long burners" leaving them, and, in return, getting our outcasts (short burners), began a very aggressive campaign, and offered all sorts of cut-rate propositions. Johnson told me to call on their manager and tell him that if he did not quit that kind of warfare, we would give him a "dig" that would hurt. You can imagine what that manager said to me.

After I had reported the result of my talk with the gas manager to Johnson, he said that we would advertise complete electric cooking outfits for $80 on time payments, and would sell current for them at two cents per kilowatt-hour. By advertising we had no trouble in assuring the public that it was cheaper, cooler, cleaner and more healthful than gas, and we put out fifty sets in two weeks. The gas manager came to me and asked me how much longer we were going to run that offer. I replied "Forever," and he went away, declaring that we would go into bankruptcy if we continued at such a price.

Johnson contended that we were making a good profit on it at two cents, as the cooking load runs as shown in Fig. 4. It is an all-day load until people begin to get their supper; the load at 5 P. M. is not worth considering, and it gradually gets heavier until after six. After we put in our new 500-KW. generator, we cannot get enough residences to fill our load curve out from five to six, so the cooking load will fill in there very nicely and only increase our expenses a little for coal. The gas manager intimated that if we would put the price up to three cents, he would quit cutting prices in the business district. But we were so strongly intrenched there that we thought we had better let the price remain at two cents, as it was a great "ad" for us.

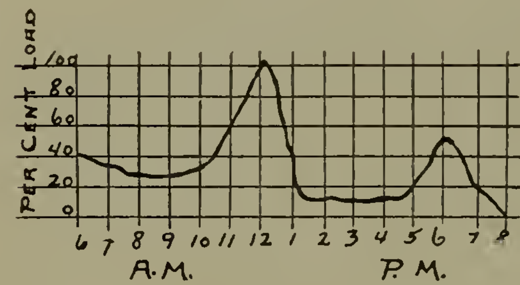


FIG. 4

As to organizing and conducting a commercial department, after my experience I can safely say: Hire the best commercial man in the country and let them do the rest. E. E.'s and M. E.'s are absolutely necessary in building and operating your plant, but don't expect them to be commercial men any more than you would expect your architect to manage your factory, office, bank or department store if he should build it.

So far the electric lighting industry has paid the high salaries to the engineers, and have employed young, inexperienced solicitors at salaries from forty to one hundred dollars per month, to market the product from an investment of sometimes millions. For that reason good salesmen have never cared to go into the electric business, and consequently to-day, when there are millions of business to be sold, there are very few men capable of selling it.

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Leading Articles

Our Purpose for 1907

BEGINNING with the December issue, THE ELECTRICAL AGE passed over to the control of Mr. John Hays Smith, who for three years has successfully managed "The Electric Journal," of Pittsburg.

The editorial department will continue under the editorial management of Mr. George W. Martin, for two years associate editor and for the past year editor of this journal.

As will doubtless be remembered, the present typographical style of THE ELECTRICAL AGE was instituted with the January, 1904, issue. Since then the editorial matter has been gradually changed over from a semi-popular nature to a more technical one.

The field covered of late has been a more or less general one, with a leaning toward the central station. For the future, however, it will be the aim of the new management to specialize in articles of interest to central station men, without neglecting the important field of industrial applications of electricity.

Of the former, we believe the articles by S. O. Newton, H. N. Müller and E. B. Raymond, given elsewhere in this issue, to be fair examples. Some of the articles of this class will appeal to the central station manager, while others will be of interest to the operating force.

The industrial articles we will aim to make unique in a way. Much of the descriptive matter appearing in the technical press dealing with industrial installations has been of little value in furnishing data for the laying out of similar work. It will be our aim to make them not only of interest to the general electrical field, but also of value to consulting engineers in planning work of this nature.

Another important feature will be a review of the technical press, more complete and extensive than yet given in these pages.

As an idea of what may be expected to appear in these pages during the coming year, a partial list of articles now in course of preparation, or arranged for, is given herewith:—

"Insurance for Electric Lighting Plants," "The Central Station vs. the Private Plant," "Electric Meters," "Steam Turbines vs. Reciprocating Engines," "Central Station Rates," "The Single-Phase Motor on Central Station Circuits," "Electric Signs," "Electric Lighting in a Large City," "Oil Switches," "Lightning Arresters," "Electric Drive in Worsted Mills," "The Industrial Applications of Induction Motors," "Gas-Power Industrial Plants," "Diagrams of Wiring Connections for Motors," "The Development in Alternating-Current Generators," "The Electrification of Trunk Lines," "Problems in the Electrification of Steam Railroads."

In addition to these will be a number of hydro-electric articles, the first of which, on a development in Colorado, will appear in an early issue, and also a number of new-business-getting articles.

The Co-operative Electrical Development Association

THOUGH it has cost us the delay of a few days in the appearance of this issue, we are glad to present to our readers a very complete report of the recent meeting in New York of representatives of the various electrical interests to consider plans for the organization of the Co-operative Electrical Development Association.

The origin of the movement has already been told in these pages and is outlined by Mr. Crouse in this issue. As will be remembered, in February of last year the incandescent lamp manufacturers appropriated an amount equal to one-fifth of one per cent. of their sales for three years, and it is with this money that the work under Mr. Crouse's supervision has been carried on. That it has been productive of good results is apparent from the table showing the result by States.

These figures are a conclusive answer to the contention of some that work of the kind carried on by Mr. Crouse had already been instituted by central stations. That many central station managers were stirred up to activity in a remarkable degree by the association's work, is apparent from the table. Nine hundred and thirty-four central stations furnish commercial data. While this is only about one-fourth of the actual number of stations in the United States, it is a very considerable percentage of the number actually soliciting the business of the public. In towns of 5000 and under only about 20 per cent. of the stations furnish a day service. For the most part, these stations are merely municipal lighting companies, though often of private ownership. The completeness of the data furnished by the stations returning information is also evidenced by the fact that not more than 1000 towns and cities in the whole United States have a population of 10,000 inhabitants and over.

The reported results are truly astonishing. At the beginning of 1906 only 58 of these central stations had organized soliciting departments; 17 stations employed direct advertising to the consumer; 29 stations made use of newspaper advertising; 38 opened display rooms, and only 8 stations in the entire United States operated their own electrical signs. This is the condition at the beginning of the year.

At the end of the year 98 more central stations, an increase of something like 150 per cent., have organized new-business departments; 232 stations, an increase of nearly 1000 per cent., have begun newspaper advertising; 165 additional, an increase of about 400 per cent., have opened up display rooms, and 181 more, an increase of about 2000 per cent., have begun the operation of their own electrical signs.

These extraordinary percentages show that in the year 1906 the central stations of the United States began direct advertising to the public, took up newspaper advertising, opened up display rooms, and began to display their own electrical signs. In this year we see the rapid spreading of new commercial methods.

During the past year also 331 new solicitors have been put to work. Assuming that a single solicitor can cover a population of 10,000, their combined efforts should reach over 3,000,000 more people, a very tangible 10 per cent. of the entire urban population of the country. All of this has been accomplished by the energetic director of the movement, Mr. J. Robert Crouse, with an expenditure of a little more than $30,000. His conservative estimate of the amount expended by the central stations themselves in new business-getting is over one-half million dollars. While the expenditure of a portion of this sum is undoubtedly due to general business prosperity, nevertheless this amount cannot be large in comparison with this total sum.

Assuming that the growth of this commercial enterprise within the year 1906 should have been as large as its stature at the beginning of the year, the increase in new business expenditure over this amount is still amazingly large.

The commercial programme outlined upon the results of the first year's work should have the careful reading of every one in the electrical industry. It is full of valuable suggestions, and gives an outline of the coming commercial developments of the industry. Mr. J. Robert Crouse and the gentlemen associated with him are to be congratulated on having demonstrated the soundness of their commercial plans.

Keeping Track of Central Station Apparatus

If a census were taken of the number of central stations in which a definite method were employed to keep track of the apparatus in service, we believe it would show a surprisingly large number deficient in this respect. In small plants, particularly, the matter may not seem of sufficient importance to warrant the use of a card or other system for purposes of recording the location, size, etc., of transformers and meters.

As pointed out by H. N. Müller, in his article on "A Card Record System for Central Station Apparatus," the record of each installation may consist merely of a vest-pocket memorandum or indefinite entries in a book, the memory of a lineman or inspector being relied on at times to fill in deficiencies. The futility of attempting to keep track of the apparatus in service by these slip-shod methods is apparent. More than one plant has suffered financially by its inability to follow up a meter or a transformer which, on the disconnection of a customer, should have been taken down and returned to stock.

Electricity in the Recent Holidays

No close observer of business auxiliaries in the recent holiday season could fail to note the increased use of electricity in the great city department stores, extending from the most elaborate schemes of special, decorative and general illumination to the operation of the widest variety of small machinery by electric motors. In central station circles Christmas week stands for the maximum rate of output of the entire year, for at that time the demands of the holidays and the coincidence with them of the shortest days in the year conspire together to produce a load which in many plants is carried with no little anxiety as to the maintenance of continuous service.

It is safe to say that the preparations for the use of electricity this year in the holidays exceeded any previous work of the kind. The remarkable prosperity of the country doubtless was a factor, leading merchants to spend liberally for electrical decorations and appliances. Another cause was certainly the vigorous organized campaigning for new business which so many central stations have pushed within the past twelve months.

Even though a large part of this extra load be withdrawn from the central station circuits at the conclusion of the holiday season, it has served a valuable purpose in pointing out that electrical methods of illumination and power supply are transcendently superior to other ways of accomplishing such results. As means of drawing extra trade these electrical displays in the holiday season are immediately productive, and their cost, large though it be in many cases, is a much smaller proportion of the total volume of business expense than similar outlays would be in the dull season.

The next few weeks will be an excellent time for the central station solicitor to press home the all-the-year-round economy of his product, with special reference to successes gained in the holidays. During the January stock taking it will pay to emphasize the point that one pays for electric power and light only when the equipment is actively at work.

Some of the most interesting applications of electricity in the department stores were in connection with the displays of children's toys. To describe the various toy locomotives, electric cars, boats, engines and other devices offered for sale more widely this year than ever before would fall without the scope of these comments, but there is no escaping the significance of such developments as an index of the omnipresence of electricity in modern life.

Much was rightly made by the salesmen of these toys of their perfect safety in comparison with the alcohol steam boilers, engines and even small turbines for sale on other counters. It is significant that the insurance authorities in some cases forbade the demonstration of the latter toys with steam, compressed air being used on account of the fire risk of the former motive power. No limitations of any kind were imposed upon the electric toys.

Far removed as the electric toy may, at first sight, appear from the commercial exploitation of electricity, we believe that the familiarity of the child with these simple applications will, in later years, tend to render his interest in electricity as a consumer more tangible. Our great commercial development of electricity is still so young that we do not realize yet the importance of having the rising generation of boys and girls enlisted in the army of intelligent users—present and prospective—of this form of energy.

The Industrial Value of Hydro-Electric Power

ONE of the most striking features of modern industrial work is the increasing demand for power which characterizes the economic advance of manufacturing and producing communities. Valuable as water-power has always been to its fortunate users, it has remained for electricity to extend its benefits far and wide. The economic advantages of being able to transmit power 200 miles or more by electricity are no greater, necessarily, in proportion to the community served, its present and potential requirements, than the value of a hydro-electric transmission of less than a score of miles to the immediate market served. Electrically transmitted power may increase the profits of doing business on a large scale in California or Utah, and at the same time it may be a potent factor in the commercial prosperity of a Vermont city or a New Hampshire town.

The study of the conditions of electric power production from the energy of falling water leads one inevitably to the conclusion that any community which can avail itself of such service at the figures now commonly charged by central station and power companies is on the road to the greatest good fortune.

Cheap power,—with rates varying from 5 down to 2 cents per kilowatt-hour,—has literally transformed many a New England hamlet from a moribund community to an energetic, live town. In some of these so-called "up-country" communities the per capita use of electricity for lighting and power service exceeds that in even large cities, rising as high as $5 per inhabitant in the territory served per annum.

Soft coal runs as high as $6.50 per ton in some of these localities, and the price of gas is often nearer $1.40 or $1.50 per thousand feet than it is $1. With power rates of 2 or 3 cents and lighting rates of 6 cents per kilowatt-hour, under conditions of this kind, it happens that the use of electricity is certainly as common, relatively, as is the use of gas in large cities which depend upon the combustion of coal for electrical generation.

The streets of these communities are lighted by electricity, instead of the dismal gas lamps of many a suburb of a great city; the hotels, stores, offices, churches and libraries are practically without exception illuminated by electricity. The methods of application may be crude, in spots, but the results are favourable. The small motor is in evidence at innumerable points; large power users are found in the street railways and the great manufacturing plants which are attracted to the place by reasonable tax requirements, good transportation facilities and low rates for electricity. In its uses of electricity a community of from 5000 to 20,000 people will often be more progressive than a city of from ten to twenty times these populations.

It needs no long-drawn list of Board-of-Trade statistics to prove that small water-powers may be as valuable to small cities as mighty cataracts to metropolitan communities. Anyone who follows the trail of the rivers of New England, for example, from their sources in the Appalachian ranges to their outlets in the Atlantic, will discover that the remoter communities which border these power-giving streams are quietly expanding in power utilization, while some of the larger Eastern cities are still discussing on paper problems of distributing systems and possible rates.

The lesson is plain: every water-power which can be pressed into commercial service on a reasonable financial basis should be improved as early as may be, and in cities where water-power cannot be had no pains should be spared to reduce the cost of generating current to the lowest terms consistent with good service. These are days of significant progress in the central station industry. With the gas engines coming more and more to the front as a prime mover of supreme economy and the lamp manufacturer on the *qui vive* to produce more and more light for a given expenditure of power, there is no need to become despondent, even if the great blessing of substantial and regular water-power is withheld. It is a bit mortifying for the dweller in a great city of one or more millions of inhabitants to find little country villages outstripping him in the power and lighting applications. Reasonable rates and a large volume of business are more in accord with the spirit of the times than high tariffs and few customers.

Index to Volume XXXVII

The index to Volume XXXVII., July to December, 1906, is now ready, and will be sent free on application to the office.

Errata

We wish to call attention to an error in the two formulæ on page 9 of this issue. It will be apparent from a glance that the fraction following the base of the Napierian logarithm should be the exponent of the base and not a separate factor, as shown.

From the World's Technical Press

Steel Poles on High-Tension Lines

THE advantages of using steel poles on high-tension transmission lines, not only at special points, such as river crossings or valley spans, but also on the whole line, are discussed by L. Kalir in the "Elektrotechnik und Maschinenbau."

When the transmission voltages reach 60,000, the distance between conductors is usually made 6 feet or more, while the distance of any one line from the pole exceeds 3 feet, so that the cross-arms, with the massive insulators, weighing from 15 to 25 pounds each, make necessary the use of powerful supports, which are difficult to attach to single or even double wooden masts.

The fact that the life of a wooden pole is only from eight to fifteen years, means that constant replacement becomes necessary in a long line, and this means interruption of supply unless, for instance, two independent lines on independent poles are employed. Wood under stress also is less reliable than iron, whilst the superiority of its insulating qualities is more apparent than real, as it cannot be counted on in wet weather, and the insulators must in either case be capable of withstanding the whole strain unaided. In fact, when the masts are of iron fewer of them are necessary, and consequently there are fewer insulators per mile to give trouble. In the case of iron masts special earthing of the structure is advisable, especially if set in concrete, and this earthing is best carried out by a steel rope,—say, 25 square millimeters in section,—carried from pole to pole above the working conductors and frequently earthed. The rope will act both as an earthing wire and as a lightning conductor.

The cost of installing an iron mast is, of course, greater than for a wooden one; but, owing to the increased height and strength available, the number of iron poles per mile is much reduced, and by carefully taking advantage of the irregularities of the ground and placing the poles at high points and letting the wire sag in the low-lying points, the number can often be still more reduced without using extremely tall or strong masts.

TYPE.	Clermont-Ferrand.	Niagara-Toronto.	Vigevano-Milan.	A. E. G. Modification of Last.	Wooden Masts (Double Set).
Number of masts per km	10	9	9	8 small and 1 large	2 x 32
Weight of one mast, pounds	1,800	2,300	1,350	1,450 & 2,870	....
Price of masts	$760	$820	$480	$575	$335
Painting of masts	52.50	42.50	25	42.50	......
6 km. of 25 sq. mm. copper cable	780	780	780	780	740
Insulators and supports	125	112.50	112.50	112.50	400 [2 km.]
1 km. of steel earthing wire	42.50	42.50	42.50	42.50	85
Earth-plates and sundries	52.50	52.50	52.50	52.50	52.50
Setting masts	42.50	55	37.50	40	100
Mast foundations	92.50	112.50	75	80	
Fixing the wires	145	145	145	145	150
Total cost of 1 km	$2,092.50	$2,162.50	$1,750	$1,870	$1,862.50

In considering the question of the stress on the wire due to its own weight, to sleet, and to wind, the author finds that the permissible stress is the determining factor for the number of poles per mile and their strength. A factor of safety of 2 is considered sufficient, and maximum stresses of 28,000 pounds per square inch for hard-drawn copper and 9000 to 14,000 pounds for aluminum are allowed. With a minimum factor of safety of 2, allowing for wind, sleet, and lowest temperature, the normal atmospheric condition will usually give a factor of safety of about 5.

The number of poles per mile is determined by the span, the height of the pole depends on the maximum sag of the wire, and the cost of the pole varies according to its construction approximately as the square of the height or as the square root of the cube of the height.

The writer then discusses several forms of poles, and, in conclusion, gives the following cost comparison for 1 kilometer (0.621 mile) of a line consisting of six conductors of 25 square millimeters (0.04 square inch or 0.11 diameter) each mounted on steel poles of the different types and on wooden poles. Transportation of material and cost of ground are not included.

The Overload Capacity of a Steam Turbine

IN discussing steam-turbine characteristics in a recent paper before the American Society of Mechanical Engineers, H. Holzworth said that the overload capacity of a steam turbine can be accomplished with or without by-passing steam to the low-pressure zone. Without by-pass steam it can be accomplished by raising the inital pressure and keeping the exhaust pressure constant, or by raising exhaust and initial pressures simultaneously.

Admitting live steam to the low-pressure parts of the turbine does not necessarily involve a considerably larger output at the switchboard. This additional steam can be supplied to the original steam that worked already in the h. p. zone, either with its full static pressure and no initial velocity (at least insignificant against the velocity of the original steam), or with a high initial velocity and a static pressure equal to that of the original steam at the inlet of the by-pass steam.

In the first case the by-pass steam exerts a back pressure upon the original steam equal to the static pressure of the by-pass steam. If this pressure is equal to the initial pressure of the original steam, this original steam cannot accomplish any useful energy in the h. p. zone at all, and all the considerably increased rotation and steam passage losses in the h. p. zone have to be entirely compensated by the l. p. zone.

In the l. p. zone of course the amount of useful energy is considerably increased. The total available energy of the steam has to be converted into useful energy only in the l. p. zone, and, therefore, increased steam velocities allow an increased weight of steam to pass through the l. p. zone.

When supplying by-pass steam to the original steam with a static pressure equal to that of the original steam at the meeting point, but with a considerably increased steam velocity, then the h. p. zone works just as before, initial and exhaust pressures being the same, and the l. p. zone has the same available energy, and, in addition, an increased weight of steam can pass through the l. p. zone, according to the very great initial velocity of the by-pass steam. Therefore, the overload can be accomplished without sacrificing the h. p. zone.

High-Voltage Tests at the Milan Exposition

SOME interesting details of high-voltage tests made at the recent Exposition at Milan are given by Messrs. Pirelli & Co. in the London "Times" Engineering Supplement. An aerial 2-wire line was constructed in a garden near the pavilion. The insulators were of the 4-petticoat type, 15.7 inches high and 12½ inches in diameter. They were rated for 60,000 volts.

The line wires were hung 5 feet 2¾ inches apart, and were made up of copper strands of various diameters—0.099, 0.14, 0.19, 0.22 inches—in order to show the difference of the brush discharge according to the diameters of the strand. The experiment was made at night. When 50,000 volts were reached, the smallest strand, of 0.099 inch diameter, began to show brush discharges, while with the biggest, of 0.22 inch diameter, the brush discharge only began at 100,000 volts.

The potential was then raised successively to 150,000, 200,000, 250,000 and 280,000 volts. At the last potential the hiss of the line was very considerable, and from the insulators, line, etc., a bright brush discharge took place. The electrostatic fields were so intense in all the neighbourhood that sparks could be obtained from any insulated metallic mass, and any vacuum glass tube lit up spontaneously. At 290,000 volts an arc sprang from one of the insulators and set fire to one of the wooden supports, thus closing the experiment.

The Economics of Electric Cooking

THE results of tests of electric heating apparatus are given by Charlotte D. Seaver, in the bulletin of the Clarkson School of Technology. The apparatus was arranged in two sets, the first consisting of a stove, an oven, a boiler, a teakettle, and a stew pan, and the second set having a stove, an oven, a boiler, and a water heater.

The results obtained with the first set are given in the following table:—

Table Showing Results of Electric Heating and Cooking.

No. of Experiment	I	II	III	IV	V
Apparatus used	Stove and tea-kettle	Oven	Broiler	Oven	Oven
Operation	Heating water	Baking bread.	Broiling	Baking cake .	Baking
Article, kind		2 Loaves	Beefsteak	Angel food	4 Apple pies
Weight (total)	2 lbs. from 42° to 212° F...	3 lbs	1.5 lbs		
Size, each		8x6x2.5 in.		10 in. tin	7 in. diameter
Time required min.					
1. From cold to effective cooking temperature		25	5	15	25
2. For operation specified		32	6.5	45	35
3. Total minutes		57	11.5	60	60
Energy required, kw.-hr.					
1. From cold to effective cooking temperature	0.1675	0.5795	0.115	0.3466	0.564
2. For operation specified		0.4525	0.158	0.467	0.773
3. Total kw.-hours		1.032	0.273	0.8136	1.337
Cost of operation, based on charge of four cents per kw.-hour	$0.067	$0.0413	$0.0109	$0.0325	$0 0535
Remarks	Efficiency found to be 57 8 p. c.				

In summarizing the advantages and disadvantages of electric cooking, the author says that at the rate of four cents a kilowatt-hour it would cost double that with gas fuel, and at the prices ordinarily paid for electricity it would cost at least six times that of gas or coal, which are the fuels most commonly used.

However, while the first cost of cooking utensils seems high, yet an outfit may be obtained for $50, consisting of an oven, a broiler, a griddle, a 6-inch stove, and a flatiron, or the following combination: a griddle, two 6-inch stoves, an oven, and a flatiron. Either of these outfits would serve for the necessary cooking for an ordinary family of from three to six people.

A very complete outfit, comprising a slate top table with several outlets for electrical connections, with cords and conductors and the following utensils: an oven, a broiler, two stoves, a coffee percolator, a quart pot, and a large kettle, may be purchased for $110. This is not so much in advance, therefore, of the ordinary complete kitchen outfit as it might appear.

Moreover, these cooking vessels are of nickeled copper, which is of longer life and is more easily kept in good order than are ordinary utensils. Those utensils that lock onto the stove give the quickest service, on account of the close contact. For highest efficiency those water heaters are the best in which the heating coils are embedded in the bottom. The efficiency of a heater of one quart capacity is about 87 per cent.

The advantages of electric cooking from the standpoint of sanitation and saving of labour consist in the fact that there is no smoke, flame, nor soot, and, of course, no ashes nor dust arising therefrom. When in use there is nothing to indicate the presence of heat, for the apparatus has the same appearance as when cold. While the cooking goes on there is little or no appreciable rise of temperature of the air surrounding the utensils. There is no vitiation of the atmosphere and practically no radiation of heat into the room, which would be of great advantage in the summer.

The apparatus may be readily accommodated on a table, thus doing away with the bulky range and its fuel. There is no labour in maintaining uniform heat, no danger of fire or explosion, and no danger of personal injury or electric shock, as the voltage of 110, which is usually employed, would not produce more than a slight burn on the fingers. Electricity is quite readily obtained for heating and cooking, and may be used, as has been shown, at a reasonably high efficiency.

The articles are of superior quality. The work of the oven, for example, is as nearly perfect as possible. The time required, from the turning on of the current to complete the baking of a given article, for instance, may be determined to a certainty. Results which have been found the best by experience may be reproduced easily with the electric oven. It will not burn the top nor the bottom of the food, but heats quickly and uniformly. No particular attention is required to be given to what the oven contains, for there is no need of changing a pan containing bread or cake to get a more favourable position. Every loaf of bread or cake may be obtained uniform in height, while all are of that delicious brown so highly desired.

The time required for cooking various articles of food is practically the same as by other methods of heating. It takes the same length of time to boil a potato of given size in one way as in another, to soften the fibre of meat, or to convert dough into perfectly baked bread. The gain in time in electric cooking comes from the heat being so quickly available. For light housekeeping and in large houses during the summer months no other method presents so many desirable features.

The author firmly believes that, in spite of the higher cost, electric cooking will win its way into public favour. The greater comfort and convenience appeal strongly to the woman doing her own work, and it is not too much to expect that electric cooking and heating may offer at least a partial and perhaps a complete solution of the domestic service problem.

A Glass of Low Resistivity

A GLASS which conducts electricity comparatively well was described by C. E. S. Phillips in a paper read recently before the British Association for the Advancement of Science. This glass may be obtained by fusing together sodium silicate and borax in the following proportions: — Sodium silicate, 32 parts; calcined borax, 8 parts. If to this mixture 1.25 parts of Powell's flint glass be added, greater stability results, and the surface is improved without any serious loss of conductivity.

A glass suitable for the cases or windows of electrostatic instruments may thus be produced, capable of being cast into plates, but on account of its low fusion point, not otherwise very workable. It may, of course, be readily drawn into rods or fibres, and takes a fine polish. The density of the glass is 2.490, and it is somewhat harder than the ordinary soda glass of commerce.

With regard to other physical properties, it shows no fluorescence under cathode radiation, is very transparent to X-rays and opaque to ultraviolet light. The specific resistance of an average sample is of the order 10^9 ohms at 20 degrees C., which, although high in itself, is exceedingly low for glass. When powdered and fused on to clean copper, it adheres well without cracking. The change of resistivity with heat, which is very marked, is being examined.

Voltages in Isolated Electric Plants

THE selection of the voltage to be used in an electric isolated plant, says "Cassier's Magazine," is a matter of considerable importance. Primarily, the cost of wiring is affected by the voltage selected; but this is not the only point at issue. If a plant is equipped with alternating-current motors without exposed contacts, with no commutators to give trouble, and well-designed switches, a higher voltage may be safely run than in the case of a direct-current installation.

A factory equipped with a 550-volt induction motor is, on the whole, a safer installation, from the standpoint of the employee, than a direct-current plant fitted with 500-volt, direct-current motors on the individual drive basis. Even though a 550-volt alternating current carries with it a maximum of over 800 volts at the peak of the wave, there is more likelihood of trouble from the commutators and exposed contacts so often found in 500 - volt, direct-current plants.

If, however, the individual direct-current drive being used,—as in a modern printing press establishment, —it is important that the switches and controllers be installed within the most convenient reach of the operators. In some of the more recent plants of this character it has been necessary to protect these switches by special insulated barriers, and it is difficult to secure all the flexibility desired without introducing the danger of serious shocks to the careless employee.

Again, it is a pretty difficult problem to build very small efficient motors for operation on 500-volt circuits, on account of the requirements of insulation. The problem has apparently been solved in some of the later plants, but it is a question if 220 volts are not a better potential for such small work. The current requirements of anything under a 5-H. P., 220-volt motor are not, as a rule, serious enough to make very much difference in the cost of wiring.

The labour item will not be radically less with the higher voltage, and it is a question if the total yearly 500-volt motor cost will show economy when fixed charges and operating expenses are carefully added.

A single accident to an employee may easily wipe out the difference in first cost of a 500-volt over a 220-volt installation, and while it is possible to so insulate the 500-volt motor and its controlling switch that no trouble will arise, it is certainly a much simpler matter to use the lower potential in plants where the employee is likely to become careless on account of daily and intimate association with the equipment. It would be unreasonable to decide in favour of the lower potentials in every case, but the matter ought to be well weighed before installing a 500-volt outfit in very small sizes of motors.

Electric Traction by Rectified Single-Phase Current

THE Paris-Lyons-Mediterranean Railway, according to "The Street Railway Journal, is carrying out a series of tests at its Paris shops on a new type of electric railway apparatus developed by Messrs. Auvert & Ferrand. This method includes what is called a "regulating rectifier," taking single-phase current from the line and supplying direct current to the train motors on the Ward-Leonard motor system.

In principle the rectifier resembles a permutator, such as is built by the Société Anonyme Egyptienne d' Electricaté.

The input side of this machine resembles the stationary primary winding of an induction motor, while the winding of the output side, which is arranged adjacent to the primary, is connected to a commutator similar to that of an armature of a direct-current generator. These two windings of the machine are stationary. The current in the polyphase primary winding produces a revolving field which penetrates into the secondary armature winding. This field generates a counter e. m. f. balancing the primary voltage, and it generates in the stationary armature conductors an alternating e. m. f. which bears to the primary e. m. f. the effective ratio of the turns of the corresponding windings.

By means of brushes on the commutator which rotate in synchronism with the revolving field a unidirectional e. m. f. is obtained from the stationary armature. The brushes are attached to a circular electromagnet which bears the same relation to the primary field as the rotor of an induction motor to the stator. An advantage of this arrangement is that the small mass of the revolving parts may be rapidly accelerated to full speed, and the time consumed in synchronizing the machine is inappreciable with that necessary with a rotary converter.

The rectifier, like the permutator, does not require a driving motor capable of handling the total power, as the rotation is only required for collecting and not for generating the transformed current. The apparatus is, therefore, considerably lighter than a motor-generator of corresponding output.

The sections of the rotating winding are roughly compared to auto-transformers whose steps are so connected to the commutator segments that the alteration of the relative position of the two sets of brushes controls the mean voltage of the direct-current side of the apparatus. Thus, all regulation of the voltage supplied to the train motors driving the train, and consequently their speed, can be effected by shifting the brushes of the rectifier entirely without the use of rheostats. The resulting rectified current is pulsating, but an impedance coil placed in the circuit to some extent improves its wave form.

The system has not yet been tried under actual traction conditions, but the Paris-Lyons-Mediterranean Railway's shop experiments have been made with a 400-KW. set, consisting of two regulating rectifiers, each having two commutators with four lines of brushes.

To approximate traction conditions, the load consisted of four series-wound traction motors which were belted to generators to measure their output easily. The rectifiers were geared together and driven by a small synchronous motor at 750 revolutions per minute, the input current being supplied from a single-phase transformer at 160 volts and 25 cycles. The voltage on the continuous-current side could be varied from 20 to about 250 volts, and the over-all efficiency of the converting system was found to be 93 per cent. at the latter, and 68 per cent. at the former, voltage.

A Polarity Indicator

IN reciting some of his "Experiences on the Road," in a recent issue of "The Electric Journal," K. E. Sommer tells of how he obtained the polarity of a 75-KW., 125-volt generator.

A complaint was made that two generators would not operate in parallel. After an examination, the connections from the generators to the switchboard were found to be correct. The generators were then tested separately with the available loads, and their behavior as to commutation, compounding, etc., was all right.

When thrown in parallel the circuit breakers opened instantly. Opposite polarity alone could have caused such sudden results, inasmuch as both generators were of the same voltage when paralleled. Apparently the switchboard voltmeter, although marked "Direct Current," was not an indicator of polarity.

The writer had no portable Weston instrument at hand. Recourse was, therefore, had to a tumbler of acidulated water in series with an incandescent lamp as a preventive resistance. This device was connected successively across the terminals of each generator. In one case bubbles appeared in the water at one terminal, in the other case at the other terminal, indicating that the generators had been paralleled when of opposite polarity. One machine was "re-flashed" from the other by passing an exciting current in the proper direction through its field winding, and no further trouble was experienced with parallel operation.

Wind-Driven Generators

IN a recent number of the London "Times" Engineering Supplement, W. O. Horsnaill gives the following rules for obtaining an approximate idea of how a generating plant driven by a windmill should be laid out to give good results in a fairly exposed position:—(1) Ascertain the mean daily load in ampere-hours in December when the evenings are longest. (2) Provide a battery of at least double this output. (3) Install a dynamo which will charge the battery in twelve hours. (4) Design the dynamo to give an approximately constant voltage over a considerable range of speed. (5) Erect a windmill of sufficient power to run the dynamo at full load with a ten-mile-an-hour wind. (6) Fit the windmill and gear to the dynamo with ball and roller bearings throughout, so as to eliminate friction as far as possible.

If a plant be laid out on these lines the cost of power, including ample allowance for capital charges, depreciation, attendance, repairs, stores, etc., will be less than if it were produced by an oil engine, and the windmill is less liable to breakdowns, as it is a slow-running and robust piece of mechanism. Another point in favour of wind power, although it has not yet been tried, is the possibility of making the plant entirely automatic, as is done for train lighting, in which case it could be locked up for weeks together without risk of injury.

There is no doubt, says the author, that recent improvements in variable-speed dynamos and high-efficiency lamps will give an impetus to the use of wind power for the generation of electric current in districts where no source of public supply is within reach.

Phase Displacements in Resistances

THE measurement of small phase displacements in various resistances is discussed by C. V. Drysdale in the London "Electrician." He found that No. 10 wire, wound in spirals about one inch in diameter, with three-eighths-inch pitch, caused an angle of lag of from 16 to 18 degrees with 50-cycle current. Constantin strip, wound in spirals about one-half inch in diameter, caused an angle of lag of less than one-tenth degree. Incandescent lamps with ordinary looped filaments may be regarded as absolutely non-inductive at fifty cycles, as no angle of lag was noticeable, although a displacement of two-hundredths of a degree could have been detected easily.

Experiments with liquid resistances did not give results agreeing entirely, but the difference was attributed to changes in the electrolyte, and not to the method. Lead plates in dilute sulphuric acid, at a frequency of fifty-three cycles per second, showed angles of lag varying from two to five degrees. In caustic potash the lag was less than one degree. In caustic soda it varied inversely with the density from one to three degrees. Iron in caustic soda gave an angle of lag of less than one degree. Aluminum in caustic soda gave angles of lag varying from thirteen degrees down.

The author's conclusion is that in all cases with liquid resistances, except where aluminum electrodes are employed, the power-factor is unity within one-half per cent. or less. In the case of regulation tests, however, the two or three degrees of lead which may be introduced by liquid resistances may appreciably improve the regulation of an alternator above that on an absolutely non-inductive load. Iron wire coils are appreciably inductive at ordinary frequencies. The large angle of lead produced with aluminum electrodes may make them of decided value for induction motor starters.

Carbon Brushes for Turbine Generators

IN a recent lecture before the British Society of Arts on "High-Speed Electric Machinery," Sylvanus P. Thompson described the improvements in carbon brushes for direct-current turbine generators.

The difficulty in applying carbon brushes to turbine generators, he said, lies in the high surface speeds of the commutators. Ordinary carbons on such commutators are not satisfactory, because if used with ordinary pressures (such as 1½ to 2 lbs. per sq. in.) they are apt to chatter if there is the slightest inequality of periphery. However light they are made, their inertia does not permit them at speeds of 2000 or 3000 revolutions per minute to follow the inequality of surface.

If, to prevent chattering, high pressures are applied, then there is further trouble, for a soft carbon will smear the commutator, and a hard carbon will score it into ridges, and in either case there will be excessive heating. Messrs. Parsons state that they have never found carbon brushes satisfactory except on one small and slow-speed machine. Messrs. Siemens-Schuckert, on the other hand, use mixed arrangements of a few carbon brushes along with a majority of metal brushes.

Recently, however, the carbon manufacturers have bestirred themselves to produce special qualities of carbon brush suitable for use with high speeds. Foremost amongst these is the Morgan Crucible Company, of Battersea, who have introduced in their manufacture several novel features. In the first place, all their brushes are made with an invisible grain in the longitudinal direction, which results in their having a low conductivity laterally, and a much higher conductivity longitudinally. This feature of stratification tends to reduce parisitic currents within the brush and to lessen the heating. The friction coefficient is also low.

Another type, known as "link-two" carbon, has the peculiarity that the longitudinal resistance is higher at one side than at the other, and of intermediate value between. Hence such brushes are of particular value for machines running in one direction only, the edge of higher resistance being the edge where the last contact is made; for if the carbon at the toe of the brush is of higher resistance, this will tend to diminish the current that is dying out, while the lower resistance at the heel will tend to augment the current that is increasing, so helping the completion of the process of commutation. The reduction of resistance in one side of the brush is facilitated by the introduction into the carbon, during manufacture, of finely divided copper.

Further experience is, of course, necessary with these brushes to ascertain whether they possess the necessary mechanical qualities to last for long periods.

Designing Lifting Magnets

AT first thought, says A. C. Eastwood in "Cassier's Magazine," it seems that the design of lifting magnets for handling smooth, homogenous magnetic material, such as plates, slabs, blooms, etc., should prove a very simple matter, involving nothing more than a consideration of elementary and well-understood laws of the magnetic circuit. This has not been found to be the case; and, in fact, it is probable that there is no other type of electrical apparatus which has so persistently defied the theoretical figures of the designer when reduced to practice. The magnetic circuit of the magnet proper can, of course, be made the subject of more or less exact circulation, but this circuit is normally incomplete, and the resulting magnetization depends upon the character of the armature,—in other words, upon the load to be lifted.

A magnet which will lift a steel ingot weighing 5000 pounds may not lift a long, thin plate weighing 500 pounds,—the armature is not only magnetically, but mechanically different. The thin plate, in addition to its small magnetic cross-section, is very flexible, and the parts of the plate which overhang the poles of the magnet introduce a bending moment tending to tear the plate from the poles of the magnet. In addition to this, when the plate is lifted, it will be set in vibration by the motion of the hoisting tackle, and this introduces a live load which must be taken care of by the magnet. The air-gap between the poles of the magnet and the load to be lifted (which depends on the smoothness of the surfaces, the presence or absence of scale, dust, snow, ice, etc.) is also an important factor, affecting both the total magnetic flux and its distribution. It may be noted also that available text-books on the subject of electro-magnets contain only a very meagre amount of reliable data relating to the traction of such magnets.

It must be evident, then, that the design of lifting magnets not only necessitates familiarity with the laws of the magnetic circuit, but also a thorough understanding of the conditions to be met and the ability to properly interpret these conditions in the design. This ability can be attained only by experiment and practical experience. Much of the success attained in the later designs of such magnets is due to persistent experiment and the gaining of experience under operating conditions extending over a period of nearly ten years.

Polyphase Systems of Generation, Transmission and Distribution

By M A. SAMMETT

From a Paper Read Before the Electrical Section of the Canadian Society of Civil Engineers

EVERY electrical development possesses some typical peculiarities which should be the determining factors in the selection of the frequency of the system as a whole, as well as the selection of the generating and distributing systems as to phases, that is, whether it should be two or three-phase.

These are the problems with which we will concern ourselves in the discussion of polyphase systems, with a transmission line of 100 miles or less and pressures up to and including 50,000 volts at the receiving end. While the paper is limited to these two considerations alone, the ground to be covered is rather wide, requiring therefore a concise treatment of various characteristics.

Every system is influenced in its design by the nature of the load, and while a purely railway system will prove most economical and satisfactory with a given frequency, and two-phase synchronous converters at the sub-stations, lighting and power companies will require a different frequency and a strictly three-phase system. To compare the advantages of the three-phase with the two-phase system and of the two principal frequencies, is the aim of this paper.

We shall take up first the question of phases.

Whatever the generation and distribution, the transmission of power is always accomplished by three-phase. This arrangement allows of most economical transmission of power with a given drop in the line. While the transmission of power is invariably accomplished by three-phase, the generation and distribution is often by two-phase.

Modern engineering practice shows, however, the abandonment of the two-phase generator in connection with hydro-electric power houses, where power is to be transmitted, and consequently transformed from two to three-phase.

It must be admitted that a two-phase system for distribution purposes is somewhat simpler to operate than a three-phase system. The two phases may be controlled independently for single-phase lighting circuits without any appreciable effect of one phase on the other.

TWO-PHASE OR THREE-PHASE?

Let us take up the generating plant first and see which of the two systems, three or two-phase, is more efficient as well as more economical.

Power House.—It is quite well known that for a given capacity, speed and voltage, at a given frequency, the three-phase generator will prove the more efficient machine. Manufacturers who standardize apparatus use the same frames and punchings for the two different types. This enables the manufacturer to turn out a better three-phase generator as to efficiency and heating, retaining the same core loss.

Switchboard.—Taking up next the switchboard, we will find that the only advantage the two-phase board has in comparison with the three-phase is the saving of one ammeter. It is standard practice to use an ammeter in each leg, therefore the three-phase board will require three ammeters.

All bus-bars, oil-switch contracts and switch compartments, all cables from generators to switchboard and from the board to the transformers are reduced in the ratio of 4:3, and while 15.6 per cent. larger cross-section of copper is required in the instance of the three-phase installation, maintaining the same current density, the 25-per cent. saving in the number of individual parts necessary for the installation will be in favor of the three-phase board.

Transformers.—The use of two transformers for a given load allows a greater individual transformer capacity, and therefore a more efficient transformer. This would have been a decided advantage favoring the two-phase system, were it not for the fact that the transmission of power is to be by three-phase. To accomplish this phase transformation by the well-known Scott connections, unless all transformers are provided with a heavier high-tension winding, the transformer capacity would of necessity be reduced, due to a higher current in the three-phase winding, namely, that of 115.6 per cent. of the normal current.

Should, however, the transformers be designed with provision made for this higher current, it would necessitate larger transformers, or, in other words, a more expensive installation. Besides this increased transformer capacity, another disadvantage must be added, that of a possible resonance with T-connected transformers for two-phase-three-phase transformers. Whenever one of the phases is open, due to a failure of making proper contact of various switches or any of the auxiliary connections, the high reactance of the high-voltage transformer will get in series with the capacity of the transmission line, and a resonance is likely to take place, with the consequent disastrous results.

Distributing System.—The considerations which held true in the discussion of the transmission line will also hold true in the distributing system. Three-phase delta connections should be made use of, since, on motor service, a complete shutdown due to a failure of one transformer must be carefully guarded against. Again, three-wire three-phase distribution will result in a saving of 25 per cent. of copper and insulators. It will reduce the maintenance expense by the same percentage.

The advantages thus enumerated show clearly the desirability of three-phase distribution from the purely commercial standpoint, and still more so from the point of view of reliability and permanency of supply.

It is imperative for the success of any central station to build up a good load and to broaden out the peak. This means securing a considerable motor load. Let us see, therefore, what are the relative advantages, comparing two and three-phase motors. The induction motor is the one upon which to base our comparison, as it is the motor in general use.

The comparison can best be made from a summary of a convention paper by Bradley McCormick, read recently before the American Institute of Electrical Engineers. Given two similar frames without windings, how shall the two-phase and three-phase windings differ in order to secure proper operation? What will be the comparative losses if the two machines are given the same rating?

1. A two-phase machine should have 22 per cent. more conductors per slot than the corresponding three-phase Y-connected machine, designed for the same voltage and flux per pole.

2. The magnetizing current is the same in both the two and three-phase machines when expressed in percentage of the current, which corresponds to the full-load output.

3. The copper loss of the two-phase machine is 12 per cent. higher than that of the three-phase.

4. The leakage factor of the two-phase machine averages 25 per cent. greater than that of a three-phase machine, therefore the power factor is lower.

Actual results show from 1 to 3 per cent. lower power factors.

These considerations show that the two-phase machine will have a higher temperature rise as a result of the higher copper loss. For the same reason the efficiency of the two-phase motor will be lower. The slip of the two-phase machine will also be greater. Tests and theoretical calculations show 20 per cent. greater slip.

Thus we see that the two-phase induction motor is a poorer motor for the central-station company, due to a poorer power factor. It is also less advantageous to the power user, as a smaller efficiency means a larger motor input for a given output.

FREQUENCY

We will take up now the discussion under the heading of frequency. The frequencies most widely used on this continent are those of 60 and 25 cycles. While other frequencies are made use of, these are the predominating ones. Let us, therefore, analyze them with a view of determining their adaptability for such developments as are under discussion in our paper. We shall make our analysis, not from the transmission point of view alone, but analyze the generating and distributing systems as well.

As far as the transmission line is concerned, the lower the frequency, the less the induction drop, the smaller the charging current and the better the regulation. It is a foregone conclusion that, as a purely transmission problem, we will have to adopt the 25-cycle frequency. Our problem, however, is more complicated. The transmission line is only a chain in the link, and, important as it is, it should not overrule the advantages of a higher frequency as applied to the distributing end of the system. In our composite problem the various advantages and disadvantages should be carefully weighed, and the selection made on the merits of advantages of the entire system, taken in its totality.

Power House.—A table of speeds of generators at 60 and 25 cycles shows a wider range of speeds, and hence a greater flexibility, when laying out a 60-cycle hydro-electric power house. Thus:

R. P. M. at 25 cycles—300, 250, 214, 187, 166, 150.

R. P. M. at 60 cycles—327-300-277, 256-240-225, 212-200, 190-180, 172-164, 156-150.

The speeds of turbine-generator units are limited by the number of wheels, type, head and output. Therefore, a wider range of speeds permissible with a 60-cycle system will enable the selection of the most efficient generator-wheel combination. Inasmuch as increased peripheral velocities will result in a decrease in active material, the selection of higher speeds will enable us to choose cheaper hydro-electric sets. The above conclusions hold true except when higher speeds call for special construction, which will rapidly increase the cost.

Switchboard.—The switchboard under the two frequencies is unaffected. All meters and potential and current transformers are designed for satisfactory operation on frequencies from 25 to 125 cycles.

Transformers.—Transformers built for 25 cycles are a much more expensive piece of apparatus as well as less efficient than when built for 60 cycles.

Incandescent Lighting, Arc Lighting, Power Service by Induction or Synchronous Motor and Railway Load.—With incandescent lighting, while 30 cycles is the limiting frequency, 40 cycles is unsatisfactory when moving objects are viewed by it. On this continent 60 cycles is the standard frequency for such a service, while 50 cycles is European practice. For arc lighting, 40 cycles is the limiting frequency. Lower frequencies are made use of in the application of the recently developed mercury-vapor converter and magnetite lamps. This new system, however, will probably have to go through a process of further experimenting. The conservative investor will still select the higher-frequency series alternating enclosed arc lamps.

Induction Motors.—From the commercial standpoint, the 60-cycle motors have a decided advantage, namely, a somewhat higher speed. Speed and cost are inversely proportional, hence the 60-cycle motor will prove the cheaper of the two. Of course, the low-frequency motors have advantages of their own, such as better starting torque, higher instantaneous, but not continuous, overload capacity and lower speeds. Unless the motors of the lower frequency are standardized for best and most efficient design the high-frequency motors are more satisfactory.

The principal factors in favour of the 60-cycle motors are better continuous overload capacity and also a cheaper product commercially as a result of higher speeds. Therefore, with equally good performance as to efficiency and heating, the 60-cycle motor will still be ahead of the 25-cycle motor.

Railway Load.—The suitability of low-frequency synchronous converters for railway work is a well-established fact. While 60-cycle synchronous converters are used for such purposes, they are rather an exception, and their operation is less satisfactory. What should then, under the circumstances, be a desirable way of supplying street-railway loads without resort to frequency changes? The latter are out of the question, due to excessive cost, besides the great reduction in the efficiency of the systems, resultant from their use.

Motor-generator sets may be and are advantageously used in this connection, and, while not possessing the advantages of 25-cycle synchronous converters, have features which make them particularly suitable for use on long-distance transmission systems, permitting of a partial or complete control of the power factor of the system, depending as to whether induction motors or synchronous motor sets are used.

Wherever large capacity is present, due to long transmission lines, induction motor-generator sets of large size can be used to great advantage. For perfect control of the power factor of the transmitted power, synchronous motors should be employed, as in this case the regulating of the field excitation allows of a close control of the power factor of the transmitted energy, allowing the maximum energy for a given current, and under certain conditions will permit of carrying the load at unity power factor in the generating and transforming apparatus and transmission line.

While the synchronous converter is the most efficient of the three means of supplying railway loads, whenever this load constitutes only the minor portion of the total output of the plant, the interests of the lighting and power load cannot be sacrificed for a most efficient conversion of the alternating current to direct current for railway purposes.

In our discussion of frequency we may conclude that for a mixed load of lighting and power, with a railway load not exceeding one-third of the total power generated, 60 cycles will be the frequency to select.

Charging Current and Regulation of the Line.—We are to take up now two more questions. These are charging current and the regulation of the line.

Let us see how the two frequencies affect our case. What will be the relative magnitude of the charging current and regulation?

Line, 100 miles long.

Load, 10,000 H. P. for each transmission circuit.

Conductor, No. 0000.

Voltage at receiving end, 50,000.

Space between conductors, 60 ins.

Charging current at 60 cycles, 23 amperes.

Charging current at 25 cycles, 9.6 amperes.

Regulation at 60 cycles—

- 100 per cent. power factor, full load 9.0 per cent.
- 80 per cent. power factor, full-load current 23.0 per cent.

(Step-up and step-down transformers included in this calculation.)

Regulation at 25 cycles (including transformer)—

- 100 per cent. power factor, full load 5.5 per cent.
- 80 per cent. power factor, full-load current 10 per cent.

The regulation and capacity or charging current are decidedly in favour of the 25-cycle transmission. The results for the 60-cycle system, while considerably in excess of those at 25 cycles, are considered quite normal for commercial purposes and, inasmuch as the increase and decrease in the load is gradual, the regulation is well within control of the central-station operators or automatic devices.

As to the railway load, this had better be carried on a separate circuit whenever a multiplicity of circuits is used in transmitting the power. In our case there are three transmission circuits.

Considering the successful operation of one of the long-distance transmission lines of 130 miles in California, where the charging current forms 40 per cent. of full-load current, and where the regulation is 40 per cent. at full load, 80 per cent. power factor, we need not hesitate to operate our line with a regulation of 23 per cent., 80 per cent. power factor.

The power factor of the system, however, is to a large extent within the control of the operating company, as it may recommend to power users such apparatus as will best serve the purposes of the system as a whole. Besides this, by employing synchronous motors, running as rotary condensers, it will be enabled to regulate the power factor of the system and keep it, if necessary, at unity.

These synchronous motors, running idle, and used supplementary to the synchronous motor-generator sets, will allow of a perfect control of the power factor of the system, reducing the regulation to 9 per cent. under full-load condition.

In conclusion, we will say that, under the conditions stated, for a mixed lighting and power load, with a railway load not exceeding 33 per cent. of the total output, a three-phase, 60-cycle system should be employed throughout, and all transformation should be accomplished by delta to delta connections.

News of the Month

Prizes for an Electrical Solicitor's Handbook

EARLY last year, it will be remembered, the Co-operative Electrical Development Association offered $1000 in prizes for papers on the organization and conduct of a new business department for central stations in cities of 50,000 population and under. These prizes were awarded by the president of the National Electric Light Association at the Atlantic City meeting on the judgment of a special committee, since which time they have been given very wide publicity through the co-operation of the electrical technical press, as well as by issues by the association in pamphlet form.

Recently the subject of offering prizes for an electrical solicitors' handbook was discussed with the co-operating committee of the National Electric Light Association, and it was decided to offer $2600 in prizes for such a production. The prize money is divided as follows:—

$1000 for the light section, of which $500 will be awarded as the first prize, $300 as the second and $200 as the third.

$1000 for the power section, of which $500 will be awarded as the first prize, $300 as the second, and $200 as the third.

$600 for the heat section, of which $300 will be awarded as the first prize, $200 as the second, and $100 as the third.

In general it is desired to secure a handbook which will be both instructive and stimulating to representatives of central stations, contractors or others who are soliciting the public for the sale of electrical service for light, heat and power. A little pamphlet is in the course of preparation containing general suggestions for the benefit of those who will compete for the prizes, and this will be very gladly sent upon request.

A committee appointed by the president of the National Electric Light Association will judge the handbooks, or sections of the handbooks, submitted, and their decision, which will be made just before the next meeting of the National Electric Light Association, will be announced at that convention, and the nine new York drafts for the several amounts distributed to the winners.

The winning contributions, or combination of winning contributions, will be made of the greatest possible benefit to the electrical business along such lines as may be later determined by the joint committee.

This affords an excellent opportunity to make a valuable contribution to the commercial progress of the art, to achieve a reputation for business progressiveness, and, withal, to be well paid for the time, thought and energy required. Prospective competitors should apply for the pamphlet, giving fuller details of this interesting contest, to the Co-operative Electrical Development Association, of Cleveland, Ohio.

Single-Phase Traction on the Erie Railroad

THE Erie Railroad, which is electrifying a portion of the main line of the Rochester division between Rochester and Avon and the branch between Avon and Mt. Morris, will soon have the distinction of being the first steam railroad to put into commercial use the single-phase system on its lines. The work was started last summer by Westinghouse, Church, Kerr & Co., and is now nearing completion. As is well known, the New York, New Haven & Hartford Railroad Company is to use the single-phase system, but trains will be hauled by locomotives, while on the Erie road the cars themselves will be equipped with motors.

Current will be supplied by the Niagara, Lockport & Ontario Power Company, which receives the current generated at the new station of the Ontario Power Company at Niagara Falls, and is now transmitting it at 60,000 volts as far east as Syracuse for use on a local electric railway system. This long transmission line, which is being constructed in duplicate, crosses the Erie at Mortimer, about five miles south of Rochester, and from that point the power company is constructing a branch line about 14 miles in length which is to supply a sub-station at Avon.

The sub-station equipment consists of three 750-kilowatt transformers of the oil-insulated, water-cooled type, which transform the 60,000-volt, three-phase current down to a 11,000-volt, single-phase current, which is to be fed directly on to the trolley wires of the Erie.

Difficult problems were encountered at Avon and Rochester in supporting the trolley wires over the tracks through the railroad yards, and a new style of overhead span wire construction was designed expressly to overcome the difficulty of carrying heavy trolley construction through a railroad yard where it is impossible to place poles between tracks. In other places it has been found necessary to resort to steel bridges to accomplish this end, but here a system of tripartite steel poles and double spans was adopted, and is believed to be fully as effective a type of construction as bridges, besides being far cheaper and much quicker to erect.

Six new passenger coaches of the interurban type are nearing completion. They will seat fifty-six passengers, and are provided with four 100-H. P. motors, which will be capable of reaching a maximum speed of from 45 to 50 miles an hour.

New York Telephone Progress in 1906

DURING the past twelve years the growth of the telephone business in New York and vicinity has been phenomenal. In 1894 there were only about 10,000 telephone subscribers in the old city of New York. During the year just closed the net gain in the entire territory of the two companies, which, generally speaking, embraces a radius of 35 miles from City Hall, was 67,000 telephones—nearly 200 a day—a gain in one year of more telephones than there are in many of the largest cities in the world.

Some idea of the stupendous nature of the New York telephone system may be gained from the following statistics, which are approximately correct, for Jan. 1, 1907:—

Number of telephones in service and under contract in combined territories of New York Telephone Company and the New York & New Jersey Telephone Company.	389,000
Number of buildings owned and occupied by telephone companies.................	60
Number of new buildings in course of construction	6
Number of square feet of office space occupied by telephone companies.............	1,094,500
Number of central offices..................	182
Total number of employees	17,000
Average number of people per telephone..	14

Although complete statistics of foreign cities are unobtainable, a comparison shows that New York has more telephones than London and the ten other largest cities of Great Britain combined; not only more than Paris, but more than all the telephones in France, Belgium, Holland, and Switzerland combined; more telephones than are to be found in the twenty largest cities in Germany.

An interesting fact in connection with this stupendous growth is that the engineering department of the companies had already foreseen this development, and had prepared their plans accordingly, thereby making it possible to take on this huge volume of new business without lessening the efficiency of the service. Extra underground cable facilities and central office stations were planned and constructed, and in the various departments schools of instruction have been installed where a large corps of future employees are in course of training, it being the policy of the companies to keep in this way three or four months ahead of the demand as regards labor.

First International Exposition of Safety Devices

SPACE is now being assigned for the exhibits of the first international exposition of safety devices, to be held at the American Museum of Natural History, beginning January 29, 1907, and continuing two weeks.

The exhibits will include safety devices for wood and metal-working machinery; stamping, grinding and polishing machines; safeguards for boilers, elevators, windlasses, cranes and hoisting machinery; textiles and building trades; safety lamps and explosives; quarrying and agriculture; chemical industries, safety from fire; railway and trolley safety.

It is earnestly desired that all those wishing to exhibit safety devices in any of the above classes should apply at once to W. H. Tolman, director, 287 Fourth avenue, New York, for space.

As the object of this exposition is to awaken the American public to the necessity of doing something to lessen the causes of accidents to American life and labor by means of a permanent museum of safety devices where all problems of safeguarding life and limb can be studied in their working details, there will be no charge for space.

The Chicago Electrical Trades Exposition

CHICAGO'S second annual electrical show, which will be held in the Coliseum from January 14 to 26, promises to be a banner exhibit. More than 30,000 square feet of the main floor of the Coliseum has been sold to 150 of the leading manufacturers and jobbers, many of whom will make displays for others, as well as themselves. Not a single branch of the electrical field will be neglected, and the exhibits, as a whole, will be greater and more elaborate than they were in the show of a year ago. At this writing there are but five spaces left on the main floor, the complete list of exhibitors being as follows:—

Armour Institute.
American Steel & Wire Co
American Telegraph & Telephone Co.
Automatic Electric Co.
Allis-Chalmers Co.
American Telephone Journal.
Ætna Stage Lighting Co.
Anderson, Albert & J. M. Mfg. Co.
American Clock Co.
American Vibrator Co.
Antiseptic Co., The.
American Electrical Novelty & Mfg. Co.
American Sewer Pipe Co.
American Electric Heater Co.
Burns, W. J.
Bryan-Marsh Co.
Bryant Zinc Co.
Brilliant Electric Co.
Bidwell Electric Co.
Beck Flaming Lamp Co.
Bigley Telephone Co.
Bishop Gutta Percha Co.
Baton Electrical Mfg. Co.
Bossert Electric Construction Co.
Crockett, W. P., Co.
Chicago Telephone Co.
Chicago Pneumatic Tool Co.
Cook, Frank B.
Cooper-Hewitt Electric Co
Central Electric Mfg. Co.
Chicago Battery Co.
Chicago Edison Co.
Crane Company.
Central Electric Co.
Chicago Lamp & Reflector Co.
Chicago Compound Battery Co.
Commonwealth Electric Co.
Crescent Wire & Cable Co.
Crawfordsville Wire & Nail Co.
Crescent Co.
Columbia Incandescent Lamp Co.
Colonial Electric Co.
Crouse-Hinds Co.
Dixon, Joseph, Crucible Co.
Dossert & Co.
Duncan Electric Mfg. Co.
Diehl Mfg. Co.
Dean Electric Co.
D. & W. Fuse Co.
DeVeau Telephone Mfg. Co.
Dale Co., The.
Dittrick-Jordan Electric Co
Eureka Electric Co.
Engineer Pub. Co.
Edwards Electric Headlight Co.
Electric Appliance Co.
Electric Rotary Floor Polisher Co.
Electric Storage Battery Co.
Electrocraft Publishing Co.
Electric Service Supplies Co.
Electrical Review.
Erwin & Co.
Electrical World.
Engineering World.
Edison Mfg. Co.
Electric Cable Co.
Enamel Metals Co. (Enameled.)
Fort Wayne Electric Works.
Federal Electric Co.
Faries Mfg. Co.
Grubbe, Emil H., M. D.
Guarantee Electric Co.
Gould Storage Battery Co.
General Electric Company.
Haller Machine Co.
Haines, J. Allen.
Holzer-Cabot Co.
Hamburger, Felix.
Hart Mfg. Co.
Helios Mfg. Co.
Hepburn Telephone Co.
Hunter Illuminated Car Sign Co.
Indiana Rubber & Insulated Wire Co.
Johns-Manville Co.
Kellogg Switchboard & Supply Co.
Keystone Electrical Instrument Co.
Lang, J., Electric Co.
Locke Insulator Mfg. Co.
Lyon Metallic Mfg. Co.
Monarch Electric & Wire Co.
Mathews, W. N., & Bro.
Metropolitan Electrical Supply Co.
McRoy Clay Works.
Miller Anchor Co.
National Carbon Co.
National Battery Co.
Nernst Lamp Co.
Nungesser Battery Co.
Nurnberg Flaming Arc Lamp Co.
New York & Ohio Co.
Nuttall Co., R. D.
Oliver Mfg. Co.
Ohio Brass Co.
Oneida Community, Ltd.
Okonite Co., Ltd.
Peabody Coal Co.
Phœnix Glass Co.
Petersen, H. A., Mfg. Co.
Peirce Specialty Co.
Public Service.
Phelps Co.
Paiste Co., H. T.
Phillips Insulated Wire Co.
Packard Electric Co.
Protected Rail Bond Co.
Reynolds-Dull Flasher Co.
Roth Bros. & Co.
Rock Island Battery Co.
Reed Electric Cordage Co.
Shelton Electric Co.
Schureman, J. L., Co.
Stromberg-Carlson Telephone Co.
Swedish American Telephone Co.
Simplex Electric Heating Co.
Schott, W. H.
Stolz Electrophone Co.
Sangamon Electric Co.
Stanley & Patterson, Inc.
Sarco Co., The.
Sterling Electric Co.
Sterling Varnish Co.
Speer Carbon Co.
The Consumers Co.
Telephony Pub. Co.
Universal Mfg. Co.
Universal Electric Storage Battery Co.
University of Illinois.
Vulcan Electric Heating Co.
Vim Company.
Vesta Accumulator Co.
Vote-Bergen Co.
Wagner Electric Mfg. Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.
Western Electrician.
Western Insulator Co.
Wilson Trolley Catcher Co.
Wire & Telephone Co. of America.
Whitney Electrical Instrument Co.

Managing Director Niesz sent a representative to New York recently to try and get a temporary installation of the Cahill telharmonic system in the coming show, but Dr. Cahill's representatives said that this would be a physical impossibility, as there is only one telharmonium completed, and that is now the beginning of the permanent installation of the New York Electric Music Company, which has commenced its service of music to clubs, hotels, cafés and residences over the New York telephone wires.

Manager Pihl, of the New York company, however, agreed to attempt a long-distance test of the telharmonic system by which an effort will be made to transmit music from the New York central station to the Coliseum during the exposition. This will require the co-operation of the Chicago Telephone Company and the American Telephone & Telegraph Company, which control the long-distance circuit.

The longest test yet made of the Cahill system was from Holyoke, Mass., to New Haven, Conn., about 100 miles. Mr. Niesz's representative also made arrangements while East for the first installation west of New York of the Moore vacuum tube light,—"electric daylight," as it is called.

Following the precedent established by the directors of the Electrical Trades Exposition Company a year ago, Managing Director Niesz is sparing no expense or effort in making the coming show the greatest and most interesting trade exposition ever held in Chicago. It will be liberally advertised, and special inducements will be offered to attract the attention of the public to the affair.

The two hundred and first anniversary of the birth of Benjamin Franklin will be marked by a special programme Thursday, January 17, and souvenirs will be distributed. Monday, January 21, will be "telephone" day, and another appropriate souvenir will be given away. Thomas A. Edison day will be observed Wednesday, January 24, an occasion for another souvenir.

During the two weeks of the exposition there will be several important meetings of electrical organizations, notably the Northwestern Electrical Association, which has its annual convention at the Coliseum, January 16, 17 and 18. This affair is usually held in Milwaukee, but as a compliment to the Chicago members of the organization, many of whom are identified with the electrical show, the meetings are held in Chicago. The Sons of Jove will have a rejuvenation on Wednesday night, January 16, and the Illuminating Engineering Society will meet Thursday, January 17. The American Electrical Salesmen's Association will have its annual meeting Wednesday, January 24.

Ellery's Royal Italian Band has been engaged for afternoon and evening concerts throughout the two weeks of the show, and the Coliseum Annex will be converted into an electrical "Midway," several new and interesting amusement features along electrical lines having been secured.

Electrical and Mechanical Progress

Motor-Driven Hoists

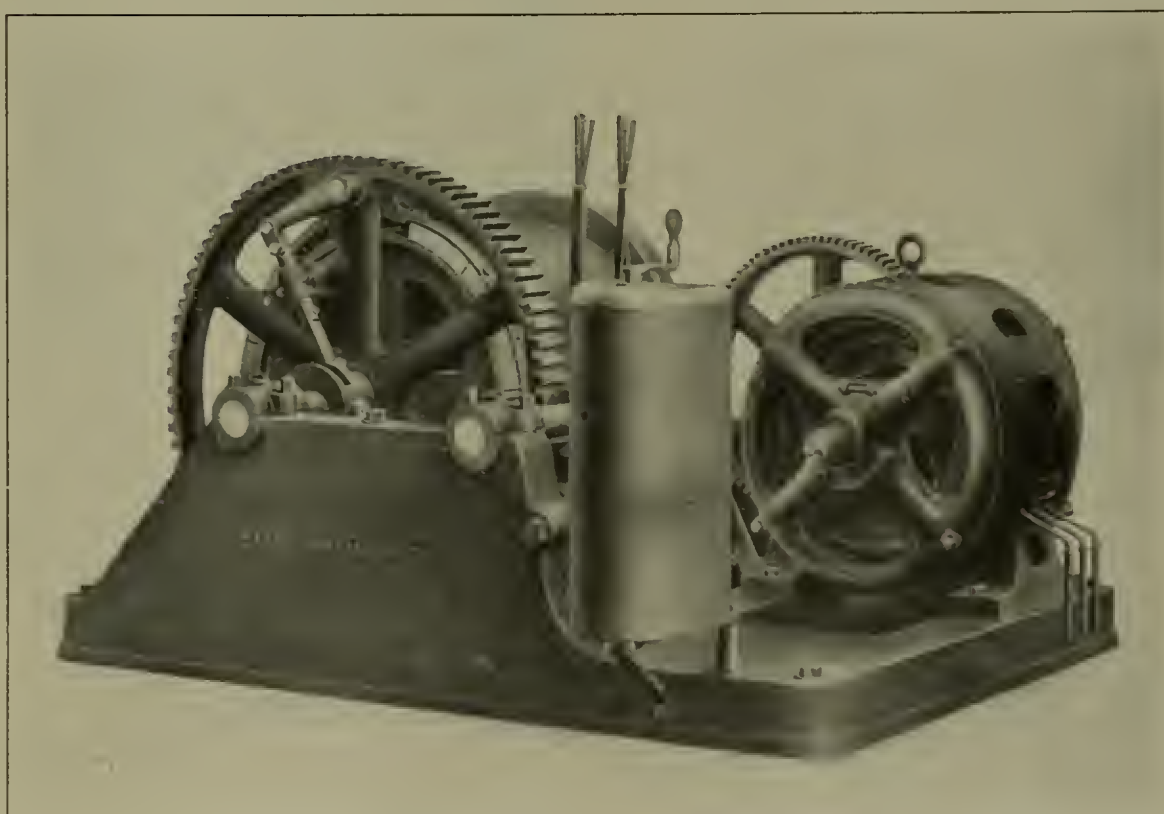
ELECTRIC hoists, in order to give the best service, must be designed and built especially to meet operating conditions. When so constructed and properly installed they are as easily handled and give as good results as steam-driven machines. For underground locations, or for places at some distance from the necessary location of the power plant, it is much easier and cheaper to run wires than pipes, thus avoiding all loss from condensation or leaks. Either direct or alternating current at any of the standard voltages and frequencies may be used, and the hoists can be built for any desired load and speed of rope.

The Allis-Chalmers Company, of Milwaukee, has recently put upon the market a line of standard machines designed to work under approximately the same conditions as its well-known small steam-driven hoist. The single-drum hoists are of 15, 25, 35, 50 and 75-H. P. capacity, and double-drum hoists are made in 30, 50, 75, 100, 125 and 150-H. P. sizes.

The drum, or drums, and motor are mounted upon a heavy, substantial bed plate of box section, with broad bearing surface on the foundation. The bearings are carried on pedestals cast in one piece with the bed plate, so that there are no bolts to work loose, and the proper alignment of the machine is thus maintained at all times.

The drum runs loose upon the shaft and is made in one piece, of the best quality of cast iron. The spider hubs are fitted with bronze bushings, which can be readily replaced in case of wear. The drum spiders have strongly ribbed arms, and the drum shell is reinforced by deep circular ribs, so that all twisting and bending strains are fully met.

The brake is of the steel band type, with a wide face, and is provided with a suitable turnbuckle adjustment for taking up the wear on the brake blocks. One end of the brake band is securely anchored by eye bars around the operating shaft, and the other end has a turnbuckle attachment to the lever on the operating shaft, controlled by the operator's hand lever.



A MOTOR-DRIVEN HOIST BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS.

The main gear, keyed on the drum shaft, forms the driving member of the clutch, which is of the band friction type. The fixed end of the band is securely anchored to the driving gear, and has suitable adjustment for shortening the band to compensate for wear. The movable end of the band is actuated by a simple and strong arrangement of toggle lever, motion to which is imparted by a collar sliding on the drum shaft and controlled by the operator's hand lever through suitable connections.

For driving these hoists the Allis-Chalmers Company furnishes either direct current or alternating-current motors wound for the usual voltages, and, if alternating current, either 25-cycle or 60-cycle machines. As the company builds a large line of motors for both direct-current and alternating-current work, it can select the type and size best suited for any particular case, and is fully responsible for the efficient working of the unit.

The controllers used with these hoists are of the drum type, similar to those in common use in street car service. On all single-drum hoists the motor is not reversed, but on double-drum hoists the handle or lever of the controller not only controls the speed, but also reverses the motor, and is locked in the off position. If desired, the lever of the controller can be made of the same design as the brake and clutch levers.

An Electric Time Switch

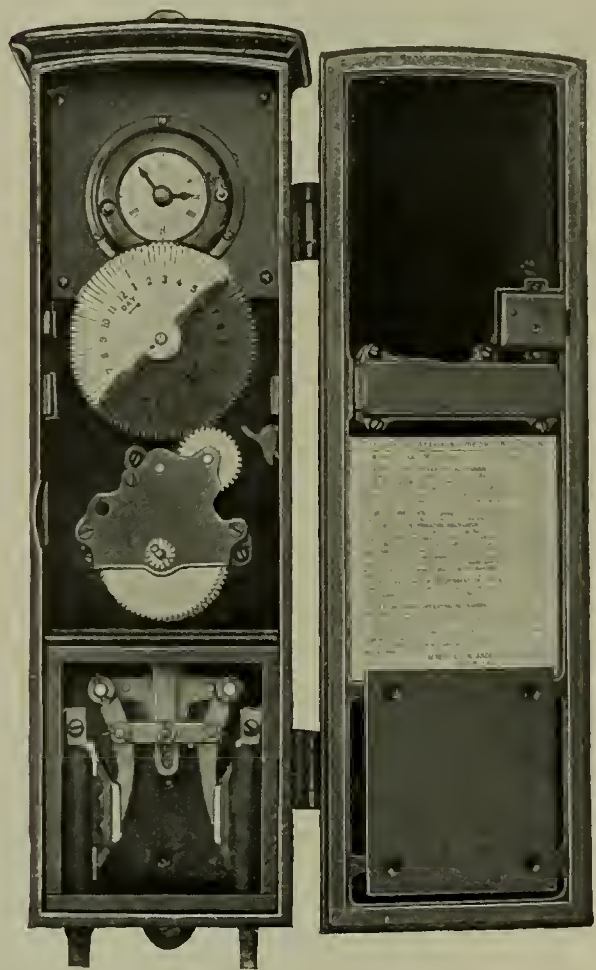
THE object of an electric time switch is to open or close an electric circuit at any desired time of the day or night with certainty and precision. The parts of a first-class time switch are three in number, namely, the switch itself, the mechanism which opens and closes it, and the time controlling element, which is necessarily a clock of some form.

In the annexed illustration is shown the switch mechanism of a time switch manufactured by the Albert & J. M. Anderson Manufacturing Company, of Boston, Mass. It consists of two pivoted arms carrying laminated contacts and arcing contacts, after the fashion of approved circuit-breaker construction. These arms are separated by a toggle motion, the central joint of which is thrust upward and downward by the propelling mechanism. When thrust downward the toggle motion is dead-centred, and it is impossible to force the laminæ from their contact seats without exerting pressure sufficient to destroy the mechanism. There is no partial or imperfect contact possible.

The contact mechanism is housed in a slate enclosure in a separate compartment of the box, and is fireproof. The lower or entering contacts are each separated from the jaws of the switch a distance of over an inch when the switch is open. The circuit is opened horizontally instead of vertically, thereby minimizing the chance of maintaining an arc.

The propelling mechanism consists of a heavy spiral spring, equipped with two trains of gears. One of the spindles of one of these trains is equipped with a crank and connecting rod, the connecting rod being utilized to force the toggle of the switch up or down. A flyer on this train engages with an escapement that permits the crank to make a half revolution at a time.

The second train of gears passes to the clock and is geared into the mechanism of the latter. Should this train of gears be released, the mechanism would at once run down. This feature is of great value, because it will be seen at once that the duty of the clock, instead of driving anything, is rather to restrain something from being driven, and instead



AN ELECTRIC TIME SWITCH MANUFACTURED BY THE ALBERT & J. M. ANDERSON MANUFACTURING COMPANY, OF BOSTON

of contributing energy to the propelling mechanism it receives energy therefrom.

The shaft on the last gear on the train running to the clock is hollow, and both the hollow shaft and the solid shaft within are equipped with trip dogs, which can be set by means of stout hands to any desired position in relation to the gear. To facilitate this setting the gear is marked with the twenty-four hours of the day, divided into quarters, and in order that the daylight and darkness hours may be distinguished, the gear is enameled black on half of its face.

A reliable clock is the heart of a time switch, and for this purpose the company has adopted one of the finest imported eight-day clocks which can be secured, and have modified it for their especial needs.

The whole switch is mounted in a three-compartment, oblong cast-iron box. The bottom compartment, lined with slate, contains the switch. The middle compartment is divided so as to open from either the back or the front, and contains the propelling mechanism. The upper compartment contains the clock. The whole is sealed with a heavy door, locked with a Yale lock, and rubber gasketed with a pressure lever, making the switch absolutely tight.

The action of the switch is as follows:—The clock and mechanism are wound and the hands are set so as to cause an event at the desired hours of the day or night. The switch is then set by the hand trigger so that the next operation shall be that desired. For instance, if the next operation is to be closure, the switch should obviously be set in an open position. As the clock permits the dial wheel to drive slowly under the impetus of the mechanism spring, it carries with it its hands and cams. The first cam engages the escapement, permitting a partial revolution of the mechanism, and a few seconds later the clock trips the escapement back again, permitting the mechanism to make a full half revolution, closing the switch. The dial wheel then proceeds as before until the second cam is brought into play, when the cycle of operations is repeated, but with this difference, the switch opens. This is repeated every twenty-four hours, unless interfered with by the seven-day wheel, which may suspend the operations of the switch on any day of the week desired.

It is, of course, possible to supply the switch with several cams which will open and close the switch several times during the day, or to omit the Sunday cut-out or other modification; but as this is not commonly required, such switches are supplied only on special order.

The uses of the time switch are manifold. The storekeeper by its use can close his store at six o'clock with the knowledge that at half-past ten, when the theatres are out, his show-window will be brilliantly illuminated, and that at twelve o'clock the lights will be out and further expense will be saved.

The central station man finds the switch invaluable when selling light to a municipality in certain locations for certain specific hours, or in supplying electric signs or other constant loads at a flat rate for certain periods of time.

The owner of a private plant supplying power to tenants can often use this switch with more satisfaction to himself and to his tenants than he could a meter. Institutions, having a certain time for "Lights Out," can use this switch to great advantage. Suburban railroads can apply it for illuminating their unattended waiting stations. Automobile charging stations will find it useful in leaving a storage battery unattended.

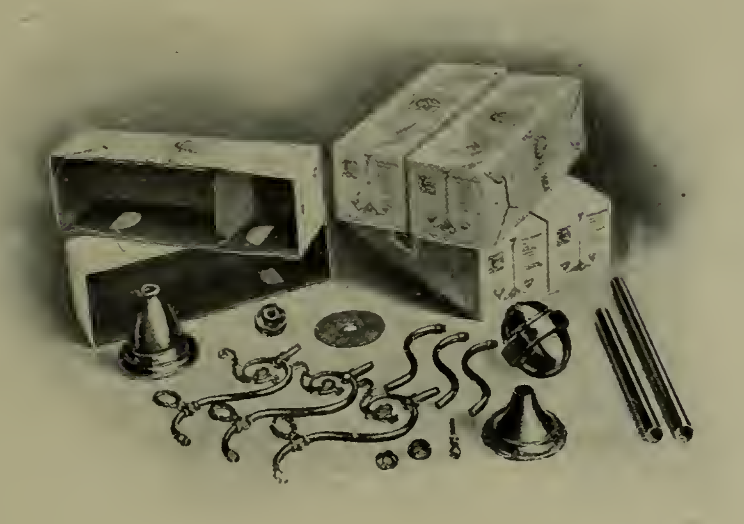
Hosts of other situations, where certain definite hours for current off and current on are required, will present themselves when the possibility of a reliable means is at hand.

Box Fixtures

THE term "Box Fixtures" has been applied by the Cleveland Gas & Electric Fixture Company, of Cleveland, Ohio, to fixtures packed in pasteboard boxes measuring 14½ by 4½ by 4½ inches. This avoids the possibility of any parts being lost, and the fixture is kept clean and untarnished until ready for installation.

Fixtures packed in this manner should prove desirable for those carrying goods in stock, as they take up but little space, permitting a large variety to be carried within a small compass. The company has deemed this method of packing of sufficient value to apply for a patent on it.

A new factory is nearing completion in Conneaut, Ohio, where the "Box Fixtures," comprehending all the requirements for low and medium-priced product, will be manufactured, with particular reference to the requirements of the market in the United States and Canada. A part of the factory is already in operation, and by January 1 the company expects to meet all orders with prompt shipments.



VIEW OF "BOX FIXTURES" MANUFACTURED BY THE CLEVELAND GAS & ELECTRIC FIXTURE COMPANY, OF CLEVELAND, O.

An attractive pamphlet, fully covering the various features of these fixtures, will be mailed on application to the company's office at Cleveland, Ohio.

The Largest Producer-Gas Power Plant in the World

THE new plant of the Iola Portland Cement Company, at Dallas, Tex., is notable for the fact that it will have the largest producer-gas power installation in the world. At other plants of the Iola Company both gas engines and steam engines have been employed, so that in selecting the type of prime mover for their new plant it was with a knowledge of the capabilities of the respective powers, and their decision was influenced by the saving in fuel consumption that was possible by the adoption of gas for power purposes.

The Loomis-Pettibone gas generating system, built by the Power & Mining Machinery Company, of Cudahy, Wis., will be furnished in three units having a total capacity of 4500 H. P. Bituminous coal and Texas lignite will be the fuels used, the Loomis-Pettibone system being adapted to the gasification of either fuel without changes in the apparatus, and the resultant gas is guaranteed to be fixed, clean and suitable for use in gas engines.

The Snow Steam Pump Works, of Buffalo, will furnish four single-tandem, double-acting gas engines, each with a normal capacity of 1100 B. H. P. These engines will be direct connected to alternating-current, 25-cycle electric generators of 810-KW. capacity each, and will operate in parallel.

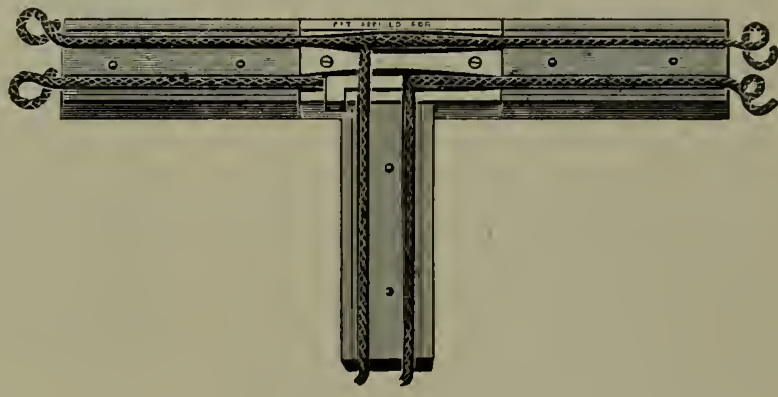
Continuous operation, twenty-four hours per day, seven days per week, is required of the power plant.

High efficiency is promised by the builders of the power apparatus, the guarantee being a kilowatt-hour at the switchboard on from 1½ to 1¾ pounds of bituminous coal or from 2½ pounds of lignite, when operating at three-quarters to full load.

A tunnel under the River Seine from Rouen to Havre is to be built by the French Government, which has retained Charles M. Jacobs, of New York, the designer of the Pennsylvania tunnels under the North and East Rivers.

Splice Protectors

IN that part of the National Electric Code dealing with the running of wires is the following:—"Careful and neat running, connecting, soldering, and taping of conductors are especially conducive to security and efficiency and will be strongly insisted on." In order to provide a ready means of fulfilling the conditions mentioned in the Code, Jordon Bros., of New York City, have placed on the market a splice protector, illustrated herewith. The protector is shown with the wires in place and minus the capping.



A SPLICE PROTECTOR MANUFACTURED BY JORDAN BROS., OF NEW YORK

The advantages claimed for this protector are that it affords a solid, substantial, soldered and insulated splice, with a fire and waterproof porcelain protection at the point where the insulation resistance of the rubber covering on the wire is impaired by the unavoidable splice; it is held in position by the capping of the moulding, and is practically invisible. No whittling of the moulding or capping is necessary, there are no exposed wires at the point where the splice is made, and there is no chance of capping nails being driven through the splice. Its use makes all work uniform, one branch being an exact duplicate of the others.

A device of this character appears to meet the demand for a better and safer class of work. It is made for two or three-wire branches or any combination of these.

Mention has already been made in these pages of the plans of the New York Electric Music Company, to transmit "electric music" over the city. Recently one of the well-known restaurants was connected up and the Café Martin is now a subscriber.

A 3-phase transmission of hydro-electric power at 50,000 volts is now under way in Spain between El Carchedo and Seville, a distance of 80 miles.

Personal

P. T. Hanscom, formerly assistant engineer of the General Electric Company, in charge of the power and mining machinery department, is now associated with Curtis & Hine, of Colorado Springs, Col. Mr. Hanscom will have charge of the electrical engineering work, and will also assist in the management of the various hydro-electric plants now being operated or under way.

W. H. Browne has resigned as director, treasurer and general manager of the Stanley Instrument Company, of Great Barrington, Mass., and has opened offices at 34 Pine street, New York. Mr. Browne has not yet made definite arrangements for the future, but anticipates the supervisory administration and managements of plants. Since 1886, Mr. Browne has been active in the electrical field. In that year he began with the organization and building of the electric railway and lighting plants at Richmond, Va., and he was associated with those interests until 1889. From May, 1888, until July, 1894, he was general manager of the United Electric Light & Power Company, of New York city. He then became receiver of the Flushing & College Point Railroad, Long Island, and from 1895 to 1902 was general manager of the Royal Electric Company, of Montreal, Can.

Allen E. Ransom has resigned as electrical engineer of the Lewiston-Clarkson Company, Seattle, Wash., to associate himself with Mr. E. W. Cummings, consulting and construction engineer, Seattle.

W. F. Hynes, construction engineer of the Allis-Chalmers Company, has just returned from Chili, where he installed a gas-driven electrical generating and air compressor plant in a copper smelting and converting works at Caldero, Chili.

S. O. Newton, for the past three years manager of the Weatherford (Texas) Water, Light & Ice Company, has severed his connection with that company. Some idea of Mr. Newton's ability as an engineer and a reorganizer may be gained from his article, given elsewhere in this issue, in which he tells of the building up of the Weatherford plant from almost bankruptcy to a good financial condition. The high regard which Mr. Newton's efforts have gained from those interested is evidenced by the following extract from a local paper:—"Mr. Newton's resignation is very much regretted by his many friends and the general public of this city, for it is due almost wholly to his efforts that Weatherford to-day stands at the head of her class in the matter of electric light and power service."

Allen E. Ransom has associated himself with E. W. Cummings, consulting and constructing engineer, at Seattle, Wash., as electrical engineer for the firm. Mr. Ransom has resigned his position as electrical engineer of the Lewiston-Clarkson Company. His headquarters will be in the Dexter-Horton Bank Building, Seattle.

Elmer D. Barry, who has been in charge of construction work for the Edison Electric Illuminating Co., of Boston, at Natick, Mass., has resigned to accept a position with the General Electric Company, Lynn, Mass. He is succeeded by William O'Brien, who has had charge of the South Framingham (Mass.) district, and who will now assume the direction of both districts.

H. M. Littell has resigned as vice-president and general manager of the San Antonio, Tex., Gas & Electric Company. W. R. Tuttle has been elected as his successor.

Walter C. Kerr, of Westinghouse, Church, Kerr & Company, of New York, has been appointed by Mayor McClellan as a member of a commission to revise the rules and regulations of city departments as to permits, and the like, for storage of building material in the streets.

Asa M. Mattice, up to last spring chief engineer of the Allis-Chalmers Company, and later engaging in consulting engineering work, has arranged to undertake the management of the works of the Walworth Manufacturing Company, and will discontinue his business of consulting engineer. His address is now care of the Walworth Manufacturing Company, South Boston, Mass.

Frank G. Baum, who has been in charge of the hydraulic and electrical engineering and construction and also the operation of the system of the California Gas & Electric Corporation for the past three and one-half years, has resigned his position in order to take up consulting engineering work, his specialty being hydro-electric power plants and long-distance transmission systems. Mr. Baum will continue as consulting engineer for the California Gas & Electric Corporation, and will have his offices in the Chronicle Building, San Francisco, about January 15. He is a member and vice-president of the American Institute of Electrical Engineers, a member of the American Society of Mechanical Engineers, and an associate member of the American Society of Civil Engineers.

The subject of central station accounting is again being actively taken up by the National Electric Light Association, and a strong committee has been appointed by President Williams to report at the 1907 convention of the association. The members of the committee are:—H. M. Edwards, of the New York Edison Company, chairman; A. S. Knight, of Boston; G. W. Curran, of the United Gas Improvement Company, of Philadelphia; C. N. Jelliffe, of the American Light & Traction Company, of New York, and Paul R. Jones, of Henry L. Doherty & Co. These gentlemen have a very thorough knowledge of the subject, and a very valuable addition to the work already done in this line by the association may be looked for.

C. E. F. Ahlm, consulting and designing engineer, of Cleveland, Ohio, has just been appointed consulting engineer for the illumination of the Garford Company's new factory at Elyria, Ohio. This factory has a total floor space of 102,000 square feet, and will be used exclusively for the manufacture of automobiles and automobile parts.

Obituary

Wallace Clyde Johnson died at Niagara Falls on December 15, with an acute attack of dilation of the heart, brought on largely by overwork, after an illness of about three weeks. Mr. Johnson was born at Granville, Mass., May 21, 1859, a son of Jares W. and Frances A. Johnson. He was educated in the public schools, and in 1880 entered Williams College, from which he graduated in 1882. In June, 1905, he received the degree of M.A. from Williams College. In 1884 he accepted a position as assistant engineer of the Holyoke Water Power Company, and in 1886 moved to Niagara Falls to accept a position as chief engineer of the Niagara Falls Hydraulic Power & Manufacturing Company, which position he held up to 1900, then becoming consulting engineer of that company, which position he held at the time of his death. While chief engineer of the Niagara Falls Hydraulic Power & Manufacturing Company he devised and installed a large part of the hydro-electric development of that company. He also designed and installed the development at Shawinigan Falls, Quebec, and was at the time of his death consulting engineer of that company. He designed and laid out many other hydraulic and electric power developments throughout the United States and Canada, including the development of the Albion Power Company, and the Hannawa Falls Company, in St. Lawrence County. He also designed and laid out, and up to within a few months of his death was chief engineer of, the Bodwell Water Power Company, in Old Town, Me. He was appointed by Governor Odell a member of the River Improvement Commission of the State of New York, and later was appointed by Governor Higgins to serve on the New York State Water Supply Commission, which position he held at the time of his death. He was a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, the Engineers' Society of Western New York, of which association he was at one time president; he was an associate member of the American Institute of Electrical Engineers, and an associate member of the Society of Arts, London, Eng.

Arthur Vaughan Abbott, well known as an engineer and author, died on Dec. 2 in New York, after a short illness. Mr. Abbott was born in Brooklyn, N. Y., in 1854, a member of a well-known family of authors and clergymen bearing his name, and graduated from the Polytechnic Institute in 1875. He was connected after graduation with the construction of the East River Bridge, and then became associated with the Daft Electric Light Company, taking part in much of its early construction of dynamos and motors and electric railways. In 1892 Mr. Abbott took up telephonic work on the staff of the Chicago Telephone Company, for which by June, 1901, when he resigned, he had constructed twelve new office buildings with their equipments and lines. He had in the meantime done considerable electric lighting work. During the past few years Mr. Abbott had been on the engineering staff of Westinghouse, Church, Kerr & Company, in New York City, doing also a great deal of work in the field. He was well known as a writer and author, his principal works being "Electrical Transmission of Energy," which has gone through several editions here and in foreign languages, and a series of six volumes on "Telephony." Mr. Abbott was a member of a number of engineering bodies, including the

ARTHUR VAUGHAN ABBOTT

American Institute of Electrical Engineers, American Society of Mechanical Engineers, and the American Society of Civil Engineers.

Trade News

The Howe Engineering Company, of which George Howe, formerly general manager of the Metropolitan Engineering Company, is president, has been reorganized with a largely increased capital. The company has recently been awarded the contract for the entire electrical equipment of the shops for the Stuyvesant High School, the contract price being nearly $70,000. For this work the company competed with the largest concerns in the country. Other deals of importance are being closed, and the outlook for the new year is distinctly promising.

The Kerr Turbine Company, of Wellsville, N. Y., through their Philadelphia agency, B. Remmers & Sons, 328 The Bourse, have secured the contract for the new power plant to be installed in the Bennett Building, Fulton and Ann streets, New York City. The power plant will consist of steam turbine generators of a combined capacity of 200 KW., will be made up of two 75-KW., 125-volt, direct-current Burke generators, direct connected to a 24-inch, 6-stage Kerr turbine, and one 50-KW., 125-volt, direct-current Burke generator, direct connected to an 18-inch, 6-stage Kerr turbine. The Kerr Turbine Company maintain a permanent exhibit in operation in the exhibition department of the Philadelphia Bourse.

The American Conduit Company, of New York, report a very rapid and healthy growth in business. They have found it necessary to occupy larger offices, and have moved from 170 Broadway to 140 Nassau street.

At the Electrical Trades Exhibition in Chicago, Dossert & Co., of New York, manufacturers of the well-known Dossert joints and solderless connectors and terminals for wires and cables, will exhibit a full line of their appliances, including many new and novel features. The booth will be located in Section F, Space No. 8.

The Power & Mining Machinery Company, of Cudahy, Wis., in conjunction with the Snow Steam Pump Works, of Buffalo, N. Y., has opened a new sales office at 719 White Building, Buffalo, where will be handled the several types of gas generating apparatus, such as the Loomis-Pettibone system suction and pressure gas plants, built by the Power & Mining Machinery Company, and the Snow gas engines, built by the Snow Steam Pump Works. Seward Babbitt, the sales manager of the first-named concern, will make his headquarters at the Buffalo office, on account of the facility for conducting business from that point.

The Virginia Portland Cement Company, of Fordwick, Va., is about to add a capacity of 2000 barrels per day to its plant, which will be one of the largest cement plants in the South. Many improvements will be made in the building and machinery; a new power house will be erected, and the existing mill will be driven by electricity. In the power house two turbines are to be installed, and the boiler capacity, increased by 1500 H. P., will now aggregate 2000 H. P. The whole of the old and new machinery will be driven by electricity. The consulting engineers of this plant are W. S. Barstow & Co., of New York and Portland, Ore. Barstow & Co. have also been retained as consulting engineers for the new plant of the Seneca Button Company, at Poughkeepsie, N. Y., which is to be operated electrically throughout, and for the Bergen Point Chemical Works, at Constable Hook, N. J., which are about to be equipped with a new light and power plant.

With the new year comes the fiftieth anniversary of I. P. Frink as a manufacturer of reflectors. Through the full line of illuminants, oil, gas, acetylene and electricity, Frink reflectors have been varied to meet changes in lighting, but always following scientific principles. Close attention has been given to the special requirements of churches, stores, art galleries, libraries and public buildings. The experience for the past year has been very much the same as that of most manufacturers of electric products,—simply a question of shipments in time to satisfy the trade. No misgivings are entertained concerning trade prospects, and the same liberal treatment that has so largely contributed to these past fifty years of success will be the portion of all the friends of Frink reflectors in the future.

The International Steam Pump Company has been compelled, by the steady advance in the cost of raw materials, to increase the prices of its products. This policy has been adopted by all other manufacturers of machinery.

The Wesco Supply Company, of St. Louis, Mo., have purchased the plant of the Davis Electric Manufacturing Company, of Springfield, Mass., including all machinery, together with all the finished and unfinished product, which is being removed to St. Louis, where the former company will continue the manufacture of the well-known "Davis switches," as well as their other specialties. The five-story factory building at the corner of Eighth street and Clark avenue, St. Louis, has been leased for a term of years, and in it is being installed the latest and most modern machinery and other equipment for the manufacture of these specialties, and also tablet boards, cut-out cabinets, switchboards, telephones and telephone accessories. The factory will be in complete operation by January 15, 1907.

New Catalogues

Air compressor lubrication is dealt with in a pamphlet recently sent out by the Joseph Dixon Crucible Company, of Jersey City, N. J. The various advantages of graphite for lubrication in air compressor work are fully set forth.

Meteorological instruments manufactured by Queen & Co., of Philadelphia, are illustrated and described in a catalogue recently sent out. The list includes thermometers, pyrometers, hydrometers, barometers and weather bureau apparatus.

Universal sockets and shades manufactured by the Henry D'Olier, Jr., Company, of Philadelphia, are illustrated and described in a bulletin recently issued. A wide variety of shades fitted with universal sockets are illustrated, together with rotating shades, adjustable portables, adjustable brackets, and air deflectors for electric fans.

Wireless clusters and lighting specialties manufactured by the Benjamin Electric Manufacturing Company, of Chicago. The list includes cluster bodies of various types, multiple and series ceiling forms, multiple and series pendant forms, weatherproof forms, arc-bursts, and a variety of brackets, sockets, receptacles, plugs, show-case fixtures and lamp guards.

Electric hoists are illustrated and described in a bulletin recently issued by the Allis-Chalmers Company, of Milwaukee, Wis. Hoists of both the single-drum and the double-drum type are dealt with, data concerning the various sizes of each type being given in tabulated form.

Head-gate hoists manufactured by the Dayton Globe Iron Works Company, of Dayton, Ohio, are dealt with in a pamphlet recently issued. The various types are illustrated and their features described. In addition to head-gate hoists, the company also builds water turbines, gearing, power transmission machinery, pulp grinders and beating engines.

"Graphite as a Lubricant" is the title of a pamphlet recently sent out by the Joseph Dixon Crucible Company, of Jersey City, N. J. This is the tenth edition of a pamphlet with the title mentioned, and it has been the company's endeavour to make it a valuable source of information for engineers, mechanics and students on modern practice in the use of graphite as a lubricant. Anyone interested in lubrication will find the pamphlet worth sending for.

"A Pair of Crooks" is the title of a folder sent out recently by the National Carbon Company, of Cleveland, Ohio. On the cover is shown a burglar throwing the light of his dark-lantern on a very crooked arc-lamp carbon. On the inside of the folder is shown one of the company's "Columbia" carbons placed against a straight-edge to demonstrate the perfect condition of the company's product.

Electric mine locomotives built by the General Electric Company, of Schenectady, N. Y., are illustrated and described in an attractive catalogue recently issued. Besides the large variety of locomotives dealt with, the cost of mine haulage by this means is discussed in a number of pages, figures being given to show the saving over mule haulage. Other literature sent out by the company includes bulletins on remote control field rheostats for railway generators and rotary converters, GE-81 railway motors, and electric motors in sawmill work.

"A Few Facts About Man's Life" are given in a folder sent out by G. E. Hall, of New York. After some of the troubles encountered by a man in this world are detailed, it is recommended that the reader try Hall's mineral machine oil and forget some of these troubles.

"Paistery" is the title of an attractive folder sent out recently by the H. T. Paiste Company, of Philadelphia. In it are illustrated and described a new swivel crowfoot for use with short-stemmed fixtures, rosettes, hanger boards for multiple arc lamps, and taplets.

Hand telephones are illustrated and described in an attractive pamphlet recently issued by the Wire & Telephone Company of America, of Rome, N. Y. Hand telephones, as is well known, are those instruments combining the receiver and transmitter in one piece. Long-distance apparatus is also illustrated and described, the company claiming for it high efficiency and durability. "Houghton" binding posts are also dealt with, their special feature being that the wire is rolled flat between two conical surfaces and thus held rigidly.

In a recent address before the Leeds section of the British Institution of Electrical Engineers, George Wilkinson said that an easily realized and very substantial economy in power plants is to employ steam temperature water to feed the boilers—i. e., to bring the boiler-feed water, after it has left the economizer or other preliminary heating device, into direct contact with live steam, so that the feed-water temperature is raised before it enters the water space in the boilers to a point equal to that of the steam itself. Its adoption will secure a greater output of steam from any steam boiler using ordinary hot feed water and at an increased economy averaging at least 7 per cent., and in most cases considerably more.

Work is now under way in electrifying a local line of the London & Brighton Railway, the project being of special interest in that it is the first single-phase installation in Great Britain. The Midland Railway has also adopted this system.

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The Electrical Age Co.
New York and London

The Animas Power and Water Company

The Largest Hydro-Electric Development in Colorado

By F. O. BLACKWELL

FIG. I.—THE DIVERTING DAM AND HEADGATE AT CASCADE CREEK, A TRIBUTARY OF THE ANIMAS RIVER IN COLORADO. THE PRESENT 6000-H. P. DEVELOPMENT OF THE ANIMAS POWER & WATER COMPANY UTILIZES ONLY THE WATERS OF THIS CREEK

THE future growth of the mining industry of Colorado is largely dependent upon the development of the large bodies of low-grade ore which have been passed over in the search for bonanza deposits. Mines with rich enough ore are of course able to stand a high cost of labor and power, but the lower grade properties must be worked on a large scale with labor-saving machinery and cheap power to be profitable.

The cost of steam power, even in the mining camps reached by railroad, is seldom less than $100 per horse-power year, and, when coal has to be hauled considerable distances over mountain roads, it is generally over $200. The utilization of the energy of the mountain streams, where high falls can often be found, has been of the greatest value in lowering the cost of mining and made possible the operation of many properties that would be unable to succeed under steam power.

As there are no large rivers in Colorado, it is to high head rather than to volume of flow that we must look for any large amount of power. There is another difficulty in the wide variation of flow between the wet and dry seasons and the freezing up of the streams in the mountains during extreme cold weather. In order to get reliable power, either a steam reserve must be provided or a sufficient storage reservoir secured to equalize the flow.

The recently completed power plant of the Animas Power & Water Company, the largest water power in Colorado, supplies electrical energy to the San Juan mining district in the Southwestern part of the State. The ore, in general, is of a medium grade, requiring much power for milling and concentration. Hence, electric power at a comparatively low cost is of the utmost importance.

The properties of the company are located in San Juan and La Platta Counties, between the towns of Silverton and Durango, on the Animas River. The stream between these two points flows through a deep and narrow canyon, with a total fall of approximately 1800 feet. The ultimate water-power development contemplated by the Animas Company, as shown in Fig. 2, includes the construction of diverting dams on the Animas River, Cascade and Lime Creeks, together with the necessary waterways for conveying the flow of the streams to a large reservoir, from which a flume leads to a small forebay, located 1000 feet above the Animas River, flowing in the canyon below. From the forebay, the water falls through riveted steel pipe to the water wheels in the power house.

When all the power generated in power house No. 1 is sold, it will be possible to make another development by means of a high dam about 3 miles below the present generating station. From this dam, with 2½ miles of waterways, a head of 500 feet can be developed.

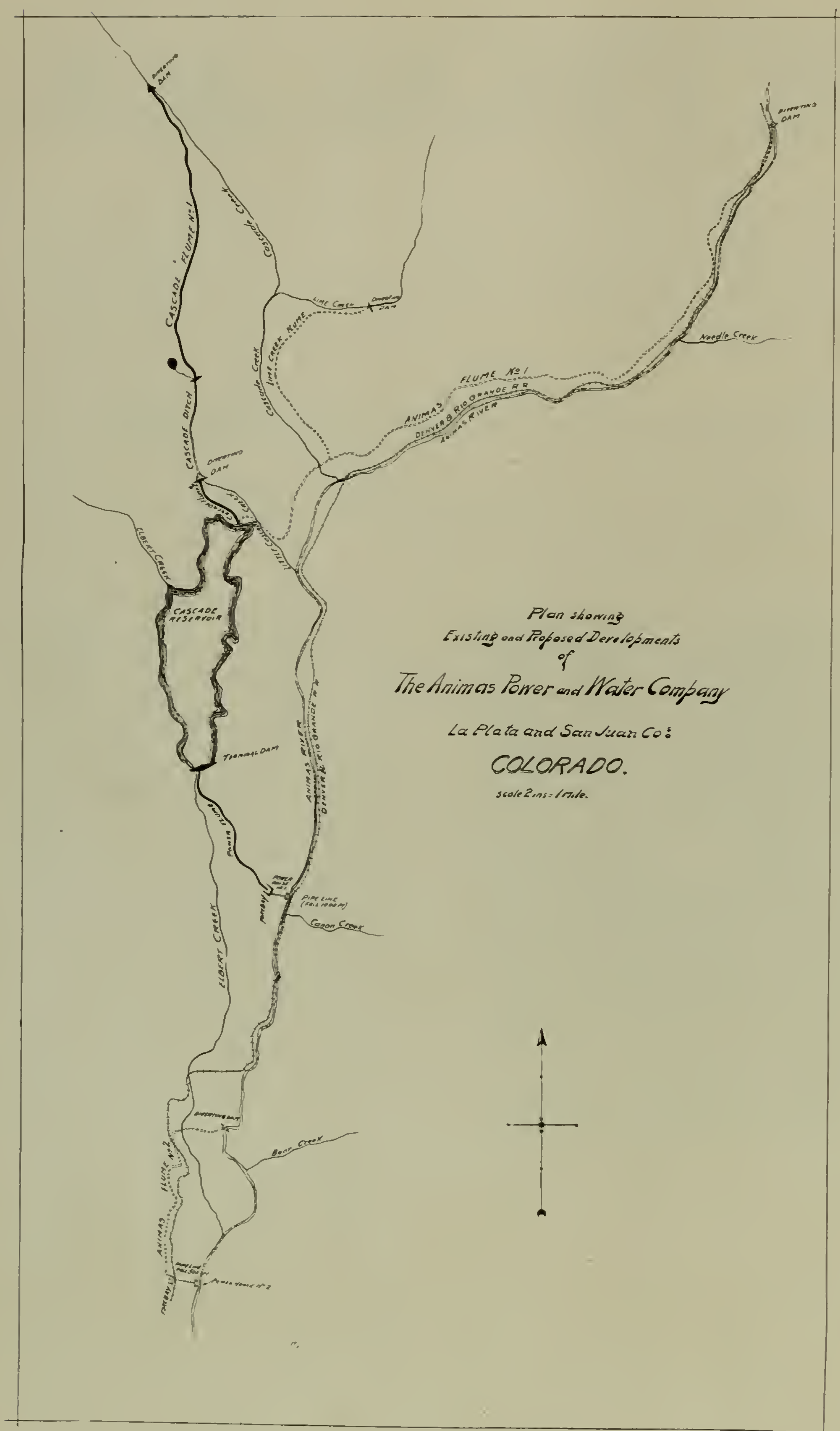

FIG. 2.—A PLAN OF THE EXISTING AND PROPOSED DEVELOPMENTS OF THE ANIMAS POWER & WATER COMPANY IN COLORADO

The present water-power development of the company, which has a rated capacity of 6000-H. P., utilizes only the waters of Cascade Creek. This stream above the diverting dam has a drainage area of 30 square miles, the average elevation of which is approximately 12,000 feet above sea level. The total area tributary to the large storage reservoir, however, is about 48 square miles, the additional 18 square miles being the catchment area tributary to the reservoir itself.

Before proceeding with the construction of the Animas plant, a measuring weir was constructed on Cascade Creek, near the site of the present diverting dam, and the depth of water flowing over the weir was carefully gauged by taking hourly readings throughout the day for a period of one year. From these discharge measurements, together with a study of the rainfall records and other stream measurements made in Southwestern Colorado on rivers having similar characteristics to Cascade Creek, it was estimated that the annual run-off of the drainage area above the reservoir would never be less than 70 per cent. of the minimum precipitation of 14 inches, and that there would always be sufficient water to operate the plant.

The discharge of Cascade Creek is very fluctuating, varying sometimes as much as 100 per cent. during a single day, due to the freezing up of the stream during the winter nights, followed by the subsequent thawing during the day. The storage reservoir is sufficient to equalize the yearly run-off from the catchment area tributary to it, and the power plant is therefore independent of any fluctuations in the flow of the stream.

DAMS AND FLUMES

A small dam has been constructed on Cascade Creek to divert practically all the water of the stream to a box flume $3\frac{1}{2}$ miles long, with an inside depth of 6 feet, and a width of 8 feet. This flume leads to a natural waterway, known as Little Cascade Creek, the water flowing along the bed of the creek for a distance of $2\frac{1}{2}$ miles to a point where a second small dam has been constructed for again diverting the water into another flume of the same dimensions. The latter is half a mile long and empties into Cascade reservoir, from which point a third flume 8800 feet in length and $3\frac{1}{2}$ inches by 4 feet 8 inches in the clear, leads to the forebay.

The flume from Cascade Creek to the reservoir must be of sufficient size to carry the flood waters of the stream, while that to the forebay is designed for the equalized flow.

The largest of the waterways, Cascade Flume, was constructed to a slope of .002 or 2 feet to a thousand feet. The discharge was calculated by Kutter's formula for the flow of water in open channels, which for measures in feet is as follows:

$$v = \left\{ \frac{41.6 + \frac{1.811}{n} + \frac{0.00281}{S}}{1 + \left(41.6 + \frac{0.00281}{S}\right)\frac{n}{\sqrt{R}}} \right\} \sqrt{RS},$$

v = Velocity of flow in feet per second.
n = Coefficient of friction.
S = Hydraulic slope, or fall of water in any distance divided by that distance.
R = Hydraulic radius, or area of discharge section, divided by wetted perimeter.

For the flume in question the coefficient of friction was taken at .012. This figure is conservative and was determined by a careful study of the conditions under which the flume would operate, and from tests made on the number of flumes in actual service. The velocity as determined from the above formula with the water running to within 1 foot of the top of the flume, or at an actual depth of 5 feet, is approximately 10 feet per second. As stated, the flume is 8 feet wide in the clear so that with 5 feet of water, the capacity would be 400 cubic feet per second.

As the flume was constructed in an almost inaccessible country, where the ground is covered with snow for six months out of the year, all the work had to be carried on in the summer and fall. Saw-mills were erected on the ground and the lumber was delivered at accessible points along the line of the flume, from which points construction was started. By working mules inside the completed portions of the flume the lumber was hauled to the workmen at both ends and in this manner the work was carried to completion.

The flume consists essentially of three longitudinal stringers, with supports every 6 feet, one stringer being in the center and one at each side. The middle stringer is 6 by 8 inches, and the side timbers are 4 by 8. A yoke of 6 by 6-inch timbers, with a knee brace on each side to hold the yoke in position, was framed at every 6 feet along the length of the flume, and between these braces a smaller yoke of 4 by 6-inch timbers was framed, the latter having no knee braces. The box of the flume is made up of a double thickness of 1-inch boards laid with joints broken. All flumes are covered in order to prevent loss of water by evaporation in summer and the probability of freezing in winter.

The crib dam, which forms the reservoir, is 750 feet long at the crest, which is 50 feet above the ground. The dam has a width of 90 feet at the base and 40 feet at the top, the foundations being carried 33 feet below the natural surface of the ground to bedrock. It is constructed of round logs, 10 feet between centers, each log being fastened to the next one underneath by means of $\frac{3}{4}$-inch pins, the cribs being filled with rock. The upstream side of the dam is vertical and to assist in making it watertight, three layers of heavy planks are nailed to the facing logs. The first layer of planks is 2 inches thick, and on top of this is nailed a layer of tarred felt, which is followed by a double thickness of 2-inch boards with the joints broken. This dam is temporary, and will ultimately be replaced by a higher one of masonry, which will make a much larger reservoir.

A natural rock spillway for discharging the overflow of the reservoir to a waterway leading to the Animas River was constructed to one side of the dam.

The reservoir is 3 miles in length and 1 mile in width at its widest point, the total storage capacity being more than 1000 million cubic feet. The water may be drawn from the reservoir to a depth of 50 feet by means of two 36-inch pipes encased in concrete, the discharge to the pipes being controlled by sluice gates at the inside face of the dam.

The forebay, which covers an area of approximately five acres, was formed by constructing an earth dam with a 3-foot core wall, carried to bedrock in order to prevent leakage. The dam is 30 feet high and 100 feet long at the crest.

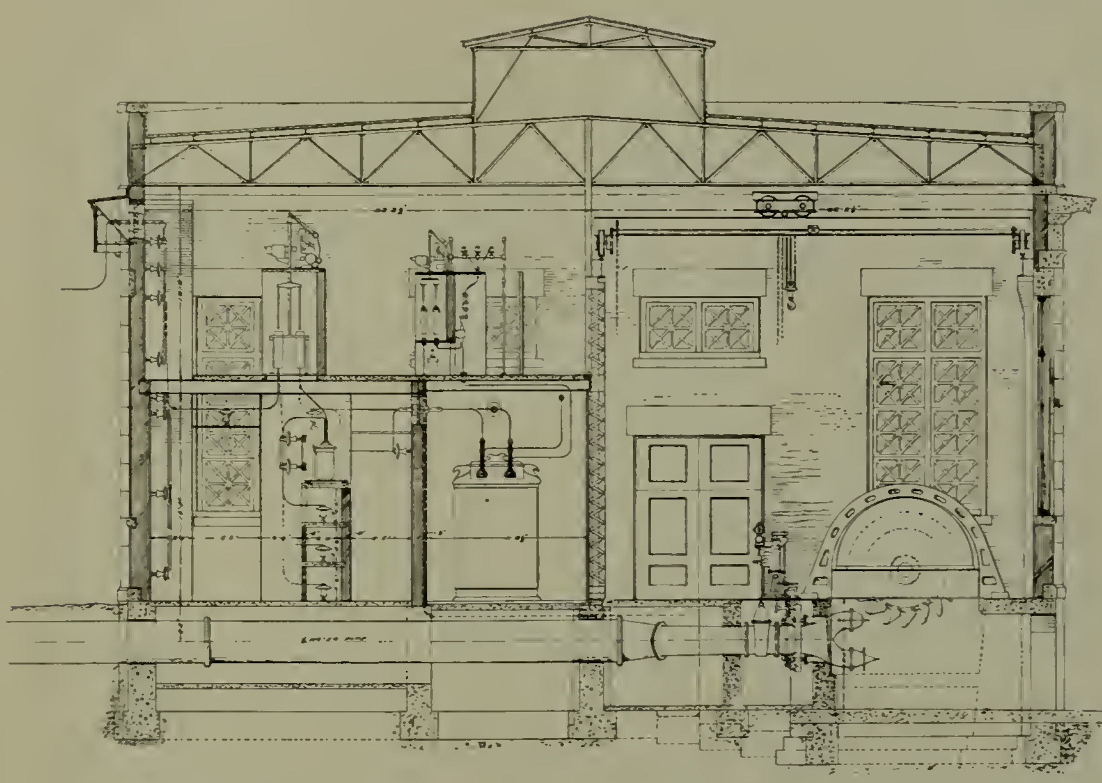

FIG. 3.—A SECTIONAL VIEW OF THE POWER HOUSE, SHOWING TRANSFORMERS, SWITCHES, AND GENERATING UNITS. THE ELECTRICAL EQUIPMENT WAS SUPPLIED BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, AND THE HYDRAULIC EQUIPMENT BY THE PELTON WATER WHEEL COMPANY, OF SAN FRANCISCO

PIPE LINE

The pipe line to the power house is 2800 feet long and was furnished by the Pelton Water Wheel Company, of San Francisco. It starts with a conical section of riveted steel pipe, tapering from a diameter of 60 inches to 44 inches and embedded 25 feet below the crest of the forebay dam. The formation of a vacuum in the

FIG. 4.—THE DAM AT CASCADE RESERVOIR

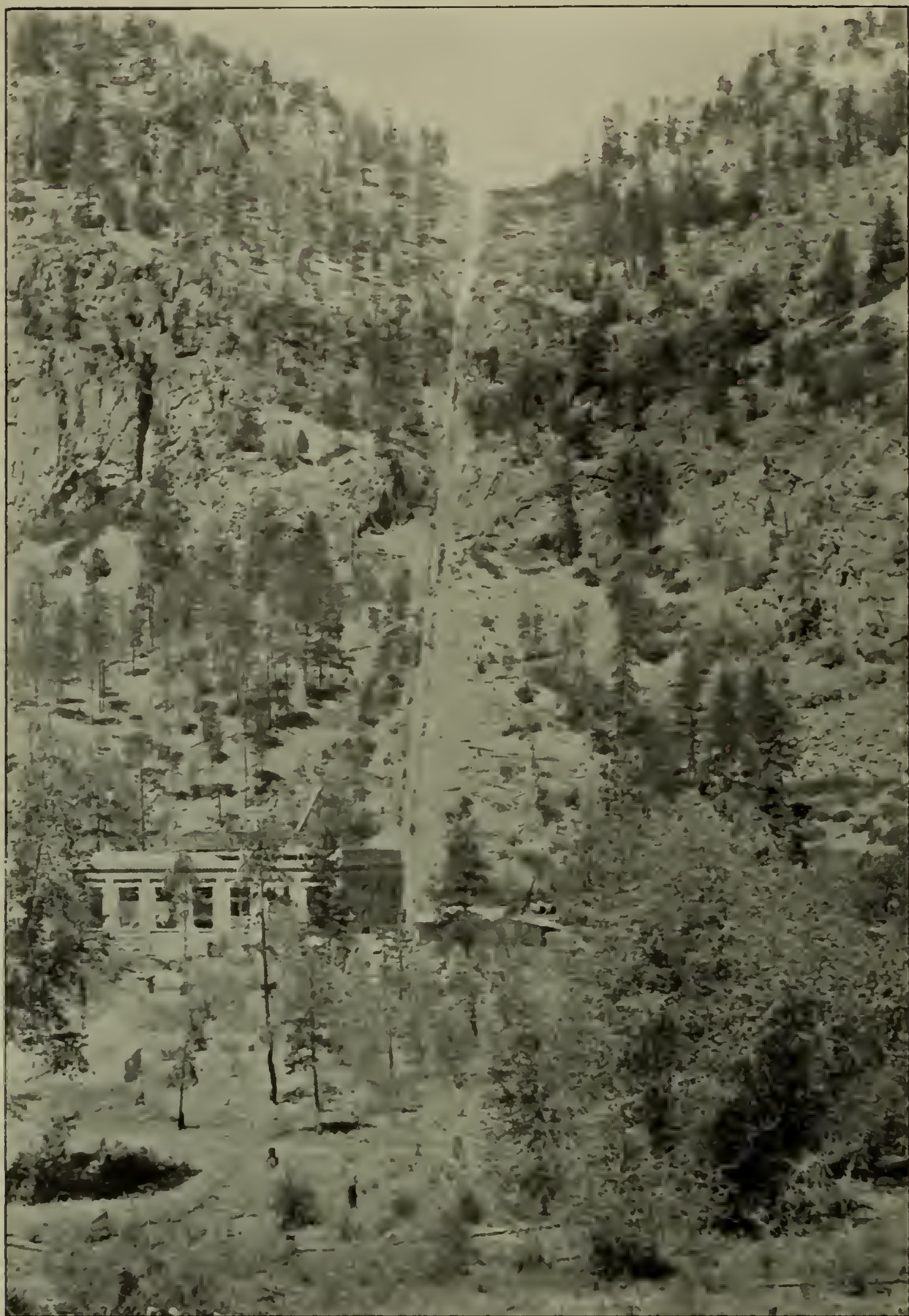

FIG. 5.—THE POWER HOUSE AND PART OF THE PIPE LINE

pipe line is prevented by the erection of a 10-inch standpipe on top of the steel pipe immediately to one side of the gate valve at the forebay. This will always insure the pipe line being filled with either water or air. The diameter of the pipe varies from 44 inches to sections of 40 inches, 36 inches and 34 inches, the largest being used at the forebay and the smallest at the power house.

The lower end of the pipe is subjected to a hydrostatic pressure of approximately 430 pounds per square inch, and is made up of 11/16-inch steel plate, double butt strapped and triple riveted in longitudinal seams, and single butt strapped and single riveted in circumferential seams. This section of pipe has also riveted to it a rolled steel flange to which is bolted a Y branch, tapering to two 20-inch outlets for connecting with the gate valves controlling the discharge of water to the two impulse wheels. The minimum thickness of pipe is at the forebay end where ¼-inch plate was used.

The pipe was made in 30-foot sections fitted with welded steel angle flanges, the sections being bolted together with composite lead and copper gaskets between these flanges. The heaviest sections weighed 6 tons each, the total shipping weight of the pipe line being nearly 700,000 pounds. All sections were tested before shipment to pressures 50 per cent. in excess of the hydrostatic pressures for which they were designed. A temporary track, mine hoist and cable were used in hauling the pipe up the bluff, the grade in some places being as steep as 85 per cent. The downward thrust of the pipe is taken up by a large concrete block at the power house, although numerous concrete piers along the line of the pipe assist in supporting and keeping it in place.

POWER HOUSE

The generating station is on the bank of the Animas River 2½ miles above the town of Rockwood and almost immediately under the forebay. The building is of substantial fireproof construction and built of concrete, brick and steel. The base is of concrete and forms the foundation for the hydraulic and electric machinery. Brick was used for the side and end walls. "Ferro-inclave" and cement are used for the roof covering, the switchboard gallery also being of "ferro-inclave" and floored with cement.

A center row of steel columns supports the roof, and also carries one line of riveted girders for a 15-ton hand-power traveling crane. The inside length of the power house is approximately 108 feet, the width

FIG. 6.—A PART OF THE PIPE LINE, SHOWING THE TEMPORARY TRACK FOR HAULING THE PIPE UP THE BLUFF FROM THE POWER HOUSE

64½ feet, and the height from the main floor to the underside of the roof trusses is 30 feet.

HYDRAULIC APPARATUS

The pipe line enters the rear wall of the building, passes through the basement and terminates in a Y branch and two 20-inch gate valves, which control the admission of water to the needle nozzles of two 3000-H. P. water wheels. These wheels are of the impulse type, built by the Pelton Water Wheel Company, and are capable of carrying an overload up to a maximum of 4000 H. P.

The effective head is 970 feet, and the wheels run at a speed of 300 revolutions per minute. They are 8 feet in diameter and are overhung on an extension of the alternator shaft, which at the bearings is 14 inches and at the revolving field 16 inches in diameter. The bearings are 42 inches long and have water-cooling coils in the lower half for keeping down the temperature of the oil. If necessary, water may also be passed through a 5-inch hole along the center of the shafts to assist in keeping the bearings cool.

Lombard oil-pressure governors are belted to the water-wheel shaft. Each is furnished with a separate oil pump of sufficient capacity for operating the two governors, and so connected that one may furnish oil for either or both governors, thus obviating the necessity of shutting down a wheel in case it is desired to make repairs on either pump.

As shown in Fig. 3, each wheel is equipped with two 6½-inch needle-nozzles, one immediately above the other, the upper controlling the admission of water to the wheels and the lower being a by-pass nozzle. By means of a system of toggle-joint levers, which are operated by the governors and connected between them and the two needles of each water-wheel nozzle, the lower or by-pass needle is opened whenever the upper needle is being closed, and *vice versa*, both nozzles being designed to secure by this means a constant discharge of water in the pipe line, irrespective of any change in load on the wheels, and thus avoid dangerous rams in the long penstock. Comparatively little water is wasted, due to varying loads throughout the day, as, by means of a hand wheel and right and left-handed screw, which is connected to the toggle-joint mechanism, the station attendant can adjust the motion of the needle nozzles, so that at the maximum load, which is likely to come on at any particular portion of the day, no water will flow through the by-pass nozzles.

ELECTRIC APPARATUS

Each water wheel drives a 2250-KW. General Electric alternator of the revolving-field type, which generates three-phase current at 60 cycles and 4000 volts. The shaft is 14 inches in diameter at the bearings and carries the water-wheel runner, the revolving field of the alternator, the armature of a direct-connected exciter and the field collector rings.

Each of the two exciters are of 50-KW. capacity and are wound for 125 volts direct current, either machine being large enough to excite the fields of both alternators.

The power house has been designed for an ultimate capacity of four of these units with water wheels. The low-potential current from the generators is raised to a potential suitable for long-distance transmission by two banks of water-cooled oil transformers, each bank consist-

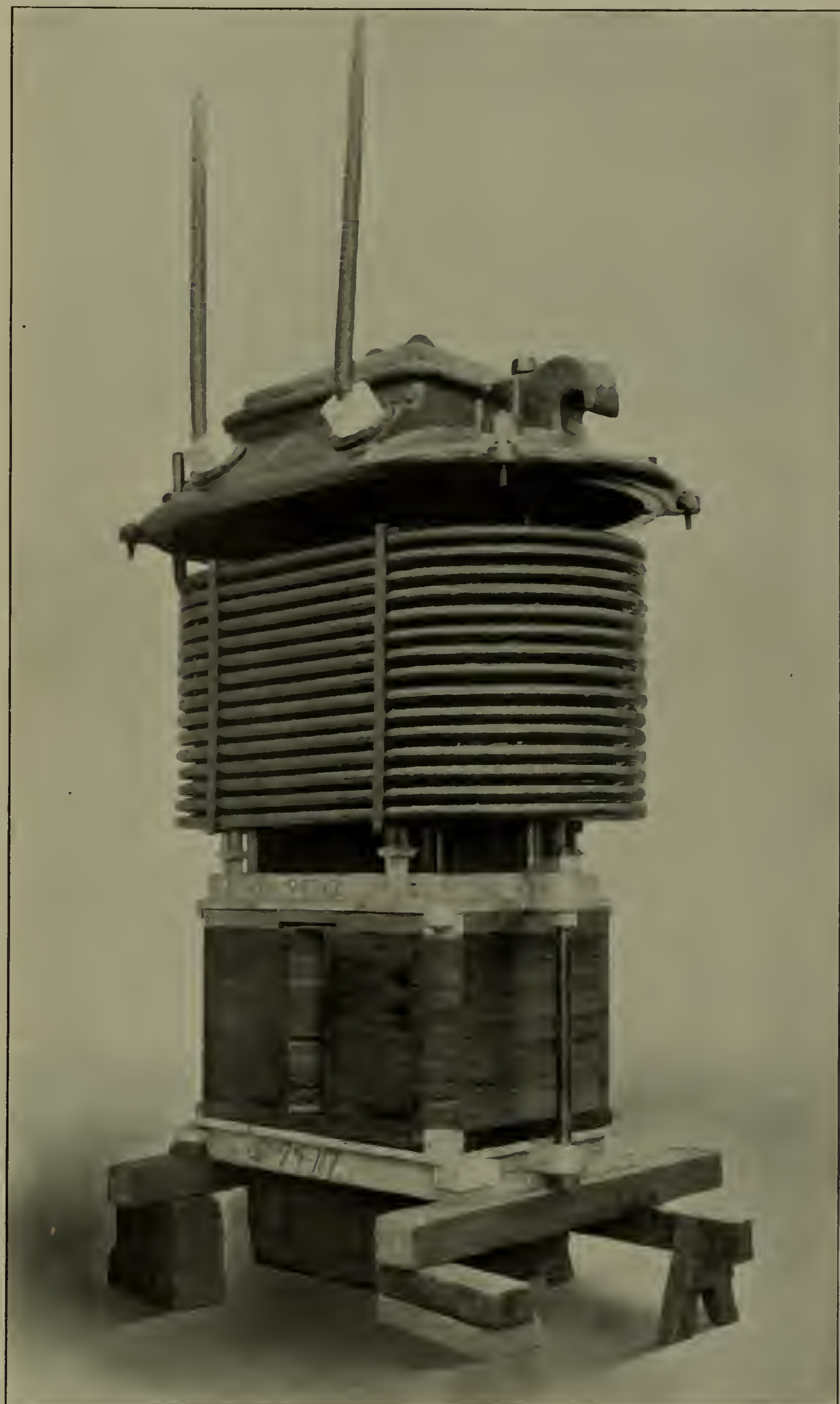

FIG. 7.—ONE OF THE 750-KW., 4000-50,000-VOLT TRANSFORMERS, BUILT BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y.

FIG. 8.—PART OF THE FLUME CONNECTING CASCADE RESERVOIR WITH THE FOREBAY. A PART OF THE TRANSMISSION LINE IS ALSO SHOWN

ing of three 750-KW. units, wound for 4000 volts on the low-tension and 50,000 volts on the high-tension side. Each transformer tank, in order to completely immerse the core and windings, carries 600 gallons of oil. and is, therefore, placed in a closed fireproof compartment separated from the generator room by steel bulkheads. A heavy sheet-iron door fastened to the bulkhead provides access to the transformers. The six compartments occupy the space immediately under and along the front end of the switchboard gallery.

The cooling coils are extra heavy wrought iron lap-welded pipe, with electrically welded joints and capable of withstanding a pressure of 1000 pounds. A water flow of five gallons per minute is sufficient to absorb all the heat generated in the transformer.

The switchboard is mounted on the gallery and consists of two combined generator and step-up transformer panels, two exciter panels, two outgoing line panels and a regulator panel. The latter controls a Tirrill regulator, which is mounted on the panel and by automatically cutting in and out resistance in series with the exciter field circuits, it maintains constant voltage across the station bus-bars irrespective of the load or power factor. It may also be connected to over-compound or increase the potential with load. The switchboard is of black enameled slate, and no high-potential leads are brought to the panels.

The 4000-volt alternator switches and the 50,000-volt transformer and line switches are of the oil type and operated by 125-volt direct-current motors, controlled from small pilot switches on the panels. All of the oil switches are mounted on the switchboard gallery and miniature red and green lamps on the panels indicate automatically whether an oil switch is open or closed.

There are two outgoing three-phase 50,000-volt transmission lines, and each line with a bank of transformers and an alternator may be operated as one unit and independent of the rest, or the two outgoing lines may be operated in multiple by closing disconnecting switches in series with the high-tension bus-bars. By means of a 4000-volt transfer bus, which is mounted on the switchboard gallery, the alternators and transformers may also be connected for parallel operation.

FIG. 9.—A PART OF CASCADE FLUME EXTENDING FROM THE DIVERTING DAM TO THE STORAGE RESERVOIR

FIG. 10.—A PART OF THE FOREBAY DAM, SHOWING THE STANDPIPE

The wiring consists of insulated cables in conduits and bare wire in brick and concrete compartments so that any damage resulting from an arc is limited and cannot injure the adjacent circuits.

Along the rear wall of the building and separated from each other by concrete walls are mounted the lightning arresters and line disconnecting switches. The high-tension bus-bar compartments are on the first floor of the building and underneath the 50,000-volt transformer and line switches, which are mounted on the gallery above. All the oil switches, transformers and alternators are equipped with air-break disconnecting switches so that they can be cut off from the system for repair and inspection.

The electrical equipment was furnished and installed by the General Electric Company, of Schenectady, N. Y.

TRANSMISSION LINES

Two wooden pole lines have been constructed from the power house to Silverton, Col., a distance of 25 miles, each pole line carrying a 50,000-volt three-phase 60-cycle circuit.

The poles were obtained from the timber of the region and range in height from 28 to 35 feet and are 7½ inches in diameter at the top.

Each transmission line is of sufficient capacity for carrying the entire output of the generating station so that in case of an accident to any one line it may be shut down for repairs without interfering with the delivery of power.

On leaving the power house the lines separate, one running up the Animas canyon and the other over the hill to the forebay and across country to Silverton.

The region traversed by the lines is frequented by numerous and destructive snow slides so that while either line is apt to be disabled from an accident of this sort it is not probable, in view of the lines running through different sections of country, that accidents of this character will be simultaneous on both circuits. Under ordinary conditions the poles are spaced 250 feet apart, but where gullies or other depressions in the ground are crossed the span was increased and wooden towers were substituted for the poles. Some of these towers are 60 feet high with a base of 20 feet, each leg of the tower being securely fastened to blocks of concrete or else anchored to bedrock. The longest spans employed were over 1000 feet.

Porcelain insulators for the transmission lines were furnished by the R. Thomas & Sons Company, of East Liverpool, Ohio. They are made in two parts and consist of a 14-inch head and a shell which were shipped separately and cemented together on the ground. Each part was tested before shipment by subjecting it while wet to a potential of 50,000 volts. The assembled insulator will withstand a wet test of 75,000 volts between the pin and conductor without arcing over. A cast-iron pin is cemented in the insulator, two of the pins being bolted to a 4 by 6-inch cross-arm, while the third is fastened to the top of the pole, the three forming a triangle with 6-foot sides.

The conductor is an aluminum cable made up of six No. 8 B. & S. specially hard-drawn wires twisted four turns per foot around a hemp core and equivalent in conductivity to a No. 2 B. & S. copper wire, and was furnished by the Pittsburg Reduction Company.

The cable was supplied in lengths of 5000 feet and joints were made by inserting both ends of the conductor in a flat aluminum tube and twisting the latter a few times so as to grip the cables, the joints so formed being as strong as the conductor itself, which has an ultimate strength of 24,000 pounds and an elastic limit of 14,000 pounds per square inch.

In putting up the aluminum wire, the sag allowed for the various spans at the different temperatures of stringing was taken in accordance with the following table:

TEMPERATURE AND SLAG IN FEET.

Span, Feet.	130° F.	100° F.	75° F.	50° F.	25° F.	0° F.
200......	3.00	2.25	1.75	1 5	1.25	1.
250......	4.25	3.5	2.75	2.	1.75	1.25
300......	5 50	4.75	4 00	3 25	2.5	2.
400......	9.50	8.25	7.00	6.	5.	4.
500......	13.25	12.00	11.0	9 75	8.25	7.
600......	18 00	16 5	15.5	14.	13.	12
700......	24 00	22.5	21.5	20.	19.	18.
800......	31.00	29.5	28 5	27.	25.5	24.
900......	38 00	36.5	35.5	34.	32.5	31
1000......	46.5	45.0	44.	42.5	41.	39 5

Size of cable........................ 103,850 C. M.
Diameter of cable.................... .39 in.
Cross section........................ 0785

Tensile strength of aluminum wire, 24.000 lbs. per sq. in.
Tensile strength of cable, 1,884 lbs.
Elastic limit of aluminum wire, 14.000 lbs. per sq. in.
Elastic limit of cable, 1,100 lbs.
Modulus or elasticity, 8,000,000.
Weight per foot of cable, .096 lbs.
Wind pressure per square foot, 20 lbs.
Wind pressure per foot of cable, .33 lbs.
Resultant of wind and weight, .35 lbs.
Allowable stress in cable, 1,000 lbs.

The table of sag and span was calculated so that under the worst conditions of strain, or at minimum temperature and a wind pressure of 20 pounds per square foot, the wire would not be stressed to more than its elastic limit. The method of calculation is fully described in the writer's paper printed in Section D, Vol. II. of the "International Electrical Congress" held at the St. Louis Exposition in 1904.

The sub-station at Silverton contains at present three 750-KW. step-down transformers and a switchboard for controlling the incoming lines and the distribution circuits. The transformers are similar to those installed in the power house with the exception that the low-tension windings are wound for 17,000 volts, which is the potential of the distribution circuits. The power is delivered to the mining regions within a radius of from 10 to 15 miles of the sub-station and at each mine step-down transformers are again installed for reducing the potential to a suitable voltage for lighting and power service.

The Ice Problem on Open-Ditch Water-Power Canals

By A. W. DAWSON

FIG. 1.—THIN SURFACE ICE JUST REACHING THE RACKING. NOTE THAT THE ICE IS BEGINNING TO BREAK UP

ONE of the problems that apparently yet remains unsolved in the design of water-power plants is the practicability of a canal and forebay with structures not affecting the efficiency, in order that a plant in the Northern part of this country may be immune from trouble and shut-downs caused by ice in its various forms. It is the contention of the writer that this matter very seldom receives the attention it deserves, the result being that a great many plants throughout this Northern country are greatly handicapped during several months of the year, either by being entirely shut down at times, or by a great reduction of power, an increased expense in the matter of wages also being incurred.

FIG. 2.—CAKE OR BORDAGE ICE LYING IN FRONT OF RACKING

The object of this article is not so much to criticise the present methods of protecting plants as to give the writer's observations regarding the peculiarity of ice during his experience in several Northern water-power plants, in the hope that the discussion may lead others to tell of their experience and thus bring out information on this important question.

Many are under the impression that anchor ice and frazil are the same thing, but this is not so. Anchor ice usually forms on the banks and bottoms of shallow streams, while frazil, as it is called in lower Canada, forms near the surface on streams or rapids where the water is much agitated. Open-ditch canals in which the velocity of water is low

FIG. 3.—SLUSH PACKED IN FRONT OF RACKING

enough to permit a surface ice to form solidly enough to hold and provide a covering gives very little trouble, and if the river or lake supply above the intake also freezes over, the plant will not be inconvenienced by ice floes. In most high-pressure pipe-line systems little trouble is experienced provided the intake is pro-

FIG. 4.—FORMATION OF FRAZIL ON A 3/4-INCH STEEL CABLE SUSPENDED IN THE WATER

tected and the entrance kept well beneath the surface. The water usually flows too rapidly in the pipe to permit of freezing to any extent, and it is generally feasible to cover the pipe line and protect it from the cold if necessary. In order to simplify matters we will consider the different formations separately, as follows: Surface ice, cake or bordage ice; slush ice, anchor ice, and frazil.

SURFACE ICE

Surface ice forms on still water or on slowly moving streams. When the temperature of the water drops to 32 degrees F., small needle-like crystals appear on the surface, and, as they increase in size and number, ad-

FIG. 5.—FRAZIL AND SLUSH CLINGING TO RACKING. NOTE HOW THE OPENINGS ARE BRIDGED OVER

here to each other, eventually forming a thin unbroken sheet of ice. The water beneath freezes to the under surface of this ice, in some places reaching a thickness of from 1 to 3 feet. However, such fortunate conditions are not usually met with.

As water powers in this country are usually designed to have a water velocity of from 2 to 4 feet per second, the ice is not frozen to the banks or walls of the canal, but moves along with the current in large sheets of thin skim ice from 1-32 to $\frac{1}{4}$ inch in thickness, varying with the temperature and velocity of the water.

The moving sheet of skim ice floats down the canal and breaks up into small pieces by coming into contact with the forebay boom, racking, or penstock walls. In passing under the boom or through the racking, these small pieces are turned over and churned up, and, provided sufficient time is occupied in getting from that point to the wheels, the nature of the ice will sometimes change from that of a thin flint-like crystal to a more spongy substance, which gathers together possibly in bunches, causing a loss of power as it passes through the wheels. This ice does not adhere to the wheels as readily as anchor ice or frazil, but when

FIG. 7.—A VIEW OF THE UNDER SIDE OF RACKING AFTER THE WATER HAD LOWERED A FEW FEET IN THE FOREBAY. NOTE THAT THE OPENINGS ARE ENTIRELY CLOSED BY ICE SHUTTING OFF THE FLOW OF WATER

coming down in large quantities will, in time, cause considerable loss of power. Anchor ice or frazil mixing with it will, in a few hours, put the average low-head plant out of service.

CAKE OR BORDAGE ICE

Cake ice usually comes from ice forming to considerable thickness along the shore or edge of structures and then breaking off into large cakes which drift down the canal. These cakes are usually kept from the wheels either by booms shunting them past the penstock entrance or through spillways into the tailrace. If allowed to get to the wheels the ice cakes jam up against the turbine entrances, causing a reduction of power until worn away by the current or broken by ice chisels into small pieces to allow them to pass through the wheels or discharge outlets.

SLUSH ICE

Slush ice, as illustrated in Fig. 3, is usually caused by a heavy snowfall, especially where the canal supply is taken from a large body of open water. This slush or wet snow has no life and if agitated by being turned over in a current before reaching the penstock will break up into very small particles, which pass through the wheel and give no great trouble. If anchor ice or frazil happen to be coming down at the same time, either of these will cling to and build up on the bunches of slush as it floats along, the lower temperature of the anchor ice or frazil causing the slush to thicken up and hold together. This makes a tough, doughy formation, the adhesion properties of which increase as the temperature lowers, the mass freezing around the grating, gate rigging, and wheels.

This mixture of frazil, anchor ice, and slush, holds on much longer than anchor ice or frazil would alone at the same temperature, due, no doubt, to its greater body or volume. If the slush is coming in very large quantities and packs about the iron gratings and turbine cases, the lower temperature of the iron will at times cause the mass to freeze and harden up. This formation once frozen will hold on for several days unless broken off with ice chisels, thereby

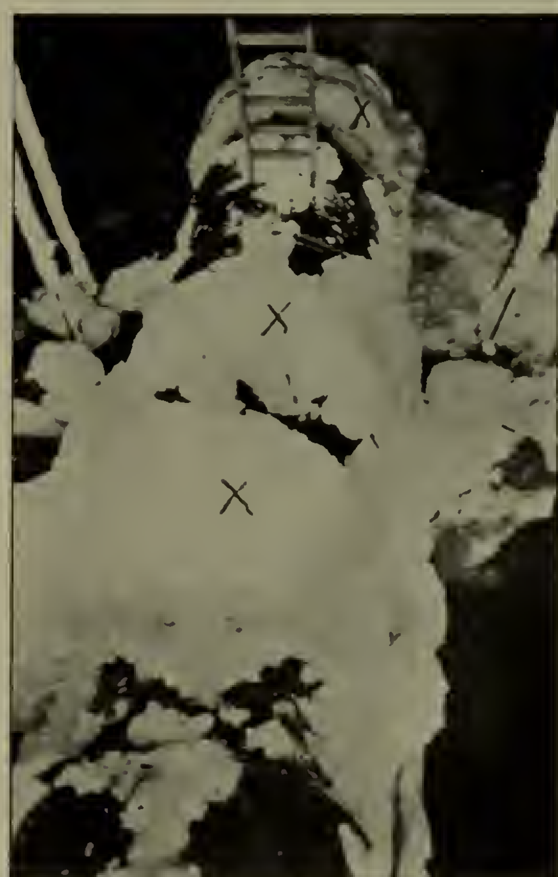

FIG. 6.—FRAZIL AND ANCHOR ICE FORMATION ON A TURBINE PENSTOCK. NOTE THE FORMATION, ABOUT 14 INCHES DEEP, OVER THE WHEEL ENTRANCES, MARKED WITH A CROSS, AND ALSO THE FRAZIL CLINGING TO THE RODS

allowing it to rise to the surface or pass through the wheels or discharge openings.

ANCHOR ICE

Anchor ice forms on the bottom and banks of streams less than 40 feet deep and has a slushy, heavy appearance like wet snow. It is caused by the bottom or banks next to the cold, running water being cooled below the freezing point, causing the adjacent water to freeze to the bottom. This formation will build upon itself until it resembles snow-covered trees or pillars on the bottom, standing at times from 1 to 3 feet high. This mass of anchor ice in time is broken away by the current or a change of temperature, and rises and drifts down stream, frequently gathering frazil as it floats along, sticking to the first object it touches, be it forebay rack, water wheel or surface ice.

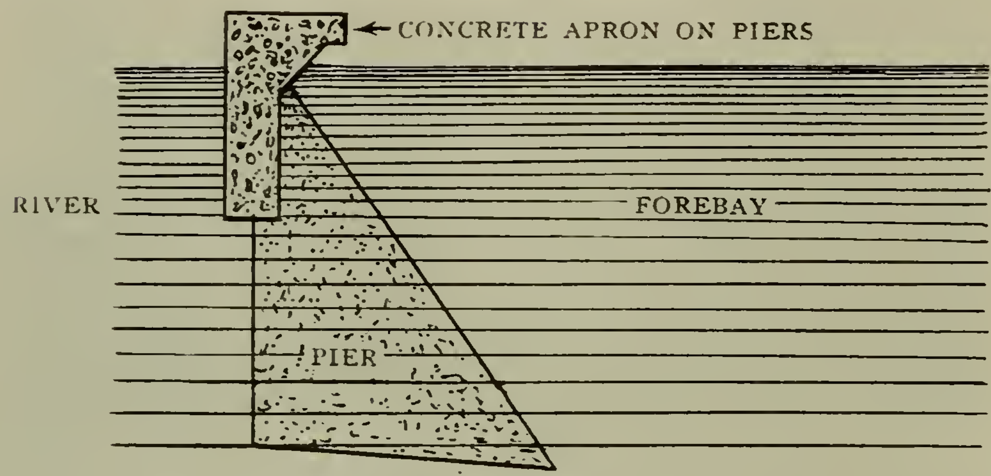

FIG. 8.—CONCRETE APRON FOR USE IN KEEPING ICE AWAY FROM RACKING AND PENSTOCK ENTRANCES

FRAZIL OR NEEDLE ICE

Frazil ice also has a peculiarity of adhering to anything it touches, but usually requires a much lower temperature to form than anchor ice, varying according to the agitation of the water. It forms near the surface on swiftly moving bodies of open water where the water is too much agitated to permit of shell or surface ice forming.

When the temperature falls low enough, the water on the surface drops slightly below the freezing point and when turned over minute crystals of feathery ice form, increasing in size until of needle or pencil shape from 1 to 6 inches long. These crystals of ice are colder than the water itself and have a peculiarity of staying with the first object they touch, building on each other very quickly, as is well illustrated by the formation upon the $\frac{3}{4}$-inch cable shown in Fig. 4. This cable was left suspended in the water at a point where the surface was much agitated, in a few hours forming the ball of ice shown.

Although the formation has a feathery, loose appearance, it is surprising how it will adhere to grating or anything else which it touches, and in a few hours either entirely shut off the water at the forebay racking by closing up the openings as illustrated in Figs. 5 and 7, or shutting down the wheel by filling around the buckets and gate openings, as shown in Fig. 6.

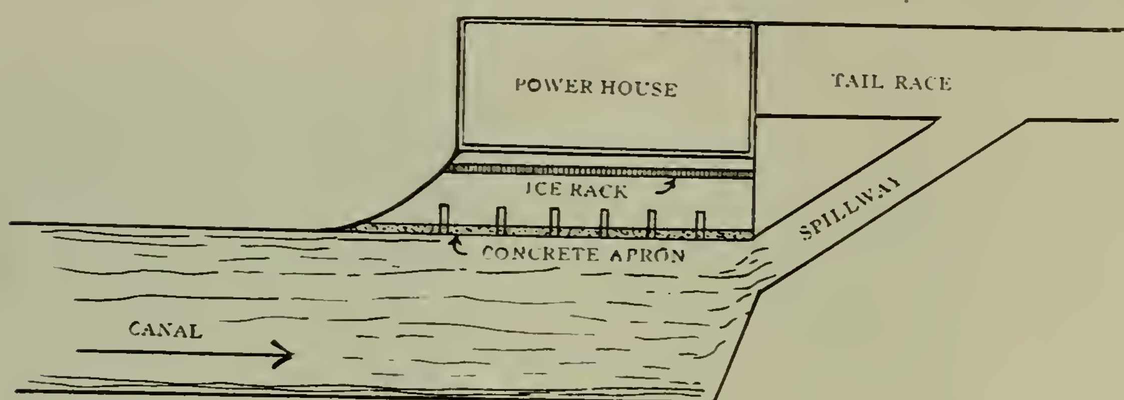

FIG. 9.—WHEN THE INTAKE IS AT RIGHT ANGLES TO THE DIRECTION OF THE CANAL, THE CONCRETE APRON IS PLACED AS HERE SHOWN

The formation of these feathery-like pencils of frazil extends only as deep as the agitation of the water below the surface. The lower the temperature the more numerous these crystals and the stronger they will adhere. While drifting under water these minute particles of ice are scarcely visible, but, as they gather together in bunches on gratings, or turbines, they present a yellow appearance. Although this formation feels soft and spongy while under water, it will freeze much more quickly than slush when exposed to the air. If, having once been exposed, even for a short period of time and then again covered with water, it will hold on much longer than those portions which were not exposed to the atmosphere.

Anchor ice and frazil very frequently visit the plant at the same time and unless the power house is fortunately situated or the canal structures particularly well designed, so as to keep the greater portion of this formation away from the wheels, operation must be suspended until the mass is ready to let go. In the majority of cases the trouble sets in toward midnight; relief may be expected between 6 and 11 A. M., depending on how bright the sun shines or how quickly the temperature rises. The writer has noticed that on a clear, bright morning, things loosen up several hours sooner than if the weather is dull and cloudy.

No fixed rule can be given regarding the velocity of water, temperature of air and water, at which anchor ice or frazil will form, as it is obvious that the results will vary, depending on the depth of streams, nature of banks, and bottoms, velocity of water, and temperature at different depths, all of which more or less influence the results. Although every plant will have to be dealt with separately, the writer is satisfied that an observant superintendent can, after a few winters' experience in the same locality, usually tell when he may expect trouble from anchor ice or frazil, provided he has established a system of records relating to the above-mentioned points.

Forebay racking is quite generally spoken of as ice racking or ice racks in describing hydro-electric plants. The writer has often wondered why this term should be used, his experience having satisfied him that the so-called ice rack in most cases is more or less of a detriment than anything else to the average low-head plant when anchor ice or frazil come down the canal. Very few ice racks are so designed that the total openings through the racking is much in excess of the total penstock entrance, the result being that the velocity of the water is increased in passing through the grating, causing the formation of frazil as mentioned above. The only usefulness of the racking during the winter months consists of stopping any cake or bordage ice which may get past the head gates or break away from the canal banks.

The main usefulness of the forebay

rack is really during the summer season, and especially in the spring and fall in preventing drift logs, sticks, bark, and other debris from getting into the wheels and causing low power, broken wheels, and gate riggings. In order to do this work efficiently and stop small sticks, the opening between the gratings should be small, not over 1½ inches near the surface and 4 inches at the bottom. A forebay rack of this description is an expensive structure during the winter months, because the openings are so small that they close up very quickly with either frazil, anchor ice, or slush. As the openings near the surface clog up, the water becomes more agitated, being turned over in getting through the gratings and thus causing the formation of frazil, which will, in time, entirely close up the openings and make a very good dam in place of an ice rack or screen. It is a common occurrence in some Northern plants for a large crew of men to be kept working night and day in the month of January and February with rakes, pike poles, and the like, keeping the so-called ice rack clear. Many power companies spend hundreds of dollars in this way.

The writer's opinion is that this work is a needless expense and the power losses would be very little increased if the racking were entirely or partly removed during the time anchor ice or frazil is flowing down the canal.

The best protection against anchor ice or frazil is in providing a deep, rather than a wide canal emptying into a large forebay, extending for a considerable distance before the wheels are reached. This forebay should be much deeper than the canal in order that the water drawn from it will not cause any great amount of current. Some plants are designed so that the velocity of the water in the forebay is less than one quarter of that in the canal. In this case the forebay would freeze over with the first cold weather, before the water becomes cooled throughout. Anchor ice coming down the canal will then loose its speed in entering the forebay and rise with the colder water and frazil to the surface and freeze to the surface ice.

In hydro-electric plants one of the most important requirements is reliability of service, so that the question of protecting the plant from ice in cold climates should be well taken care of in the design. Among water powers there is such an infinite variety of conditions that no set design will apply to all cases. For instance, it is a much simpler proposition to protect a plant which is placed on the side of a stream or canal, with its intake or penstock entrance at right angles to the flow of water down the canal, than to take care of a plant in which the penstock entrances are parallel to the current, thus forming an end dam for the canal.

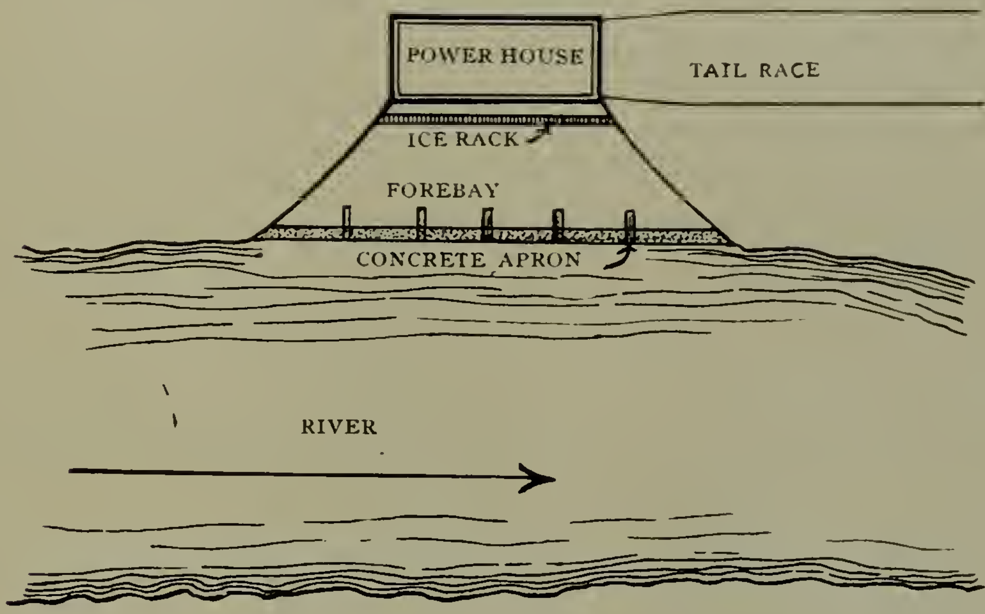

FIG. 10.—HERE THE INTAKE IS DIRECTLY FROM THE RIVER, AND THE CONCRETE APRON IS PLACED AT RIGHT ANGLES TO THE FLOW OF THE RIVER

In the former case a very good protection would be a re-inforced concrete structure on the surface extending, as shown in Fig. 8, like an apron 6 or 8 feet below the water and supported on piers in front of the racking and penstock entrances, as shown in Figs. 9 and 10. This apron will cause a strong surface current along its face sufficient to carry away all surface ice, frazil, and slush which may be floating near the surface.

For the second case a re-enforced concrete apron design similar to that in Fig. 8, forms a "V" structure across the canal—as in Fig. 11—at an angle of not more than 35 degrees to the current down the canal, leading to a spillway or "by pass." This arrangement will prevent a great deal of trouble, especially from surface ice. The spillway should be designed so as to have a strong surface current at its entrance, and sufficient drop to carry away all ice floes, logs and the like. The canal should be deep at the point where the apron is placed in order to permit of sufficient water getting under to supply the penstocks without increasing the current or drawing from the colder water near the surface. This structure will greatly assist in getting an ice covering on the forebay and canal, the frazil and surface ice adhering to it to a great extent and building on itself, in time forming an ice bridge over the surface.

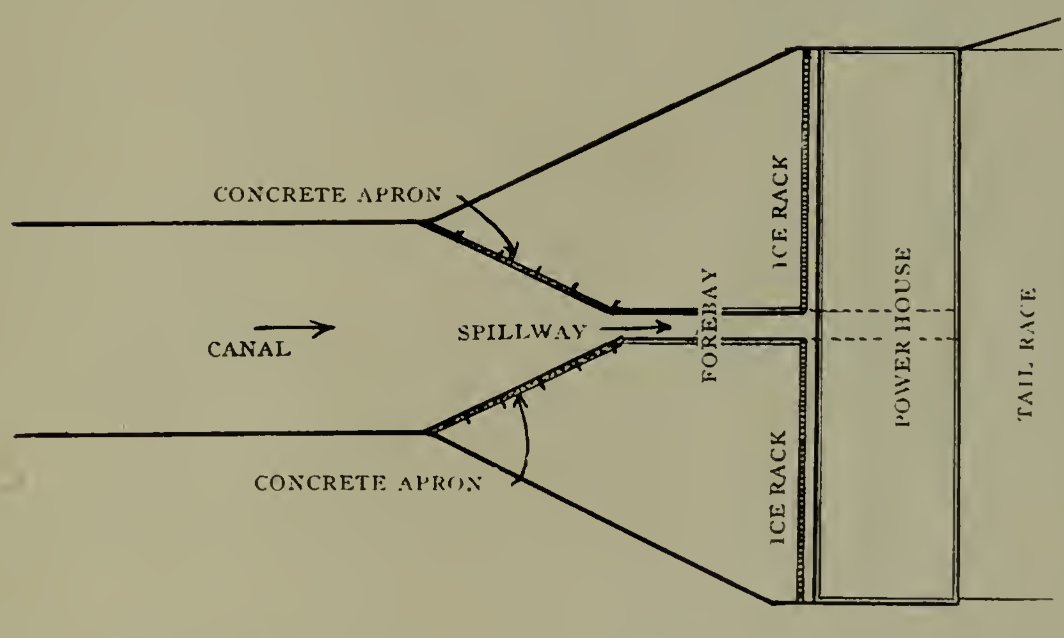

FIG. 11.—WHEN THE INTAKE IS ACROSS THE DIRECTION OF FLOW IN THE CANAL OR RIVER, THE CONCRETE APRONS SHOULD BE PLACED AS SHOWN HERE

In either case the racking should be placed as near the penstock entrance as is possible without interfering with the penstock gates or gate rigging. A very good arrangement for the racking is one in which the racks are placed on angle irons in sections, from 3 to 4 feet wide, the spacing between the racking being as mentioned above, 1½ inches on the surface and 3 to 4 inches near the bottom, the total openings through the rack being greatly in excess of the total penstock entrance below the waterline. Each section of the racking should be placed so that it can be removed and installed quickly with little labor.

In some low-head plants, especially when divided into many penstock units necessitating portable head gates for closing off the penstock entrances, a good arrangement is one in which the racking supports are so placed that the same movable equipment which raises and lowers the penstock gates may be used to raise and lower the racking.

With this arrangement, when anchor ice or frazil form on the racking and begin to close up the openings, instead of necessitating the keeping of a large crew of men working night and day to keep them clean, each section can be raised and left sufficiently high to provide enough opening at the bottom to supply the turbine. This saves the expense of a large crew of workmen, and also provides a structure which keeps all floating ice near the surface away from the wheels, the turbine supply being taken from the warmer water below. After the trouble is over the racking can be again lowered to its original position.

When the head is sufficient and other conditions will permit, the penstock entrances should be placed well beneath the surface of the water in the forebay, the turbine supply being drawn from the warmer water near the bottom, thus keeping away from the cold water and frazil formation next to the surface. Then if the forebay is large and provided with an apron as described above to keep the surface ice floes from the racking and penstock entrances very little trouble will be experienced with racking becoming clogged.

Water has the peculiarity of being heaviest at a temperature of 39.2 degrees F., becoming lighter as the temperature either rises or lowers. If the velocity of the water in the canal or forebay is low and no structure causes the water to keep turning over on itself, frazil will give little trouble, the formation not being started on account of the coldest water remaining on the surface and freezing on the surface ice.

The same rule would also apply to anchor ice, if the velocity of the water in the canal and above the intake supply is low. The cold water remains on the surface, the warmer water staying next to the bottom, thus preventing the bottom or banks being under-cooled sufficiently to gather anchor ice.

Starting a Rotary-Converter System from Rest

By JOHN E. HILL

SOME months ago a series of experiments were conducted by the operating department of the Chicago Edison Company to determine the practicability of starting from rest a rotary-converter system for lighting service, including numerous sub-stations, converting three-phase alternating current at 9000 volts into direct current at 250 volts. This conversion of current is accomplished through step-down transformers and six-phase rotary converters with a normal terminal voltage of 125 volts per side on a three-wire system, and capable of furnishing an enormous output of current.

The principal disadvantage of the high-tension, alternating-current system for lighting service, when the entire electrical energy is generated by one or two central stations, is the danger of trouble on the generating units and of short-circuits or grounds on the transmission system, which will shut down the sub-stations, with a consequent interruption of the service. Ordinarily such trouble at the generating station is quickly remedied, and the supply of energy to the sub-stations speedily renewed.

The high standard of efficiency required of sub-station operators in handling cases of trouble and also in synchronizing the rotary converters in the least possible time, has resulted in minimizing the period of such interruptions and insuring practically continuous service. This end is further secured by the installation of storage batteries with a capacity sufficient to carry the sub-station load for a period of twenty minutes or more. The accumulator is kept floating on the service bus by the switching of end cells, and if anything occurs to shut down the converters it automatically picks up and carries

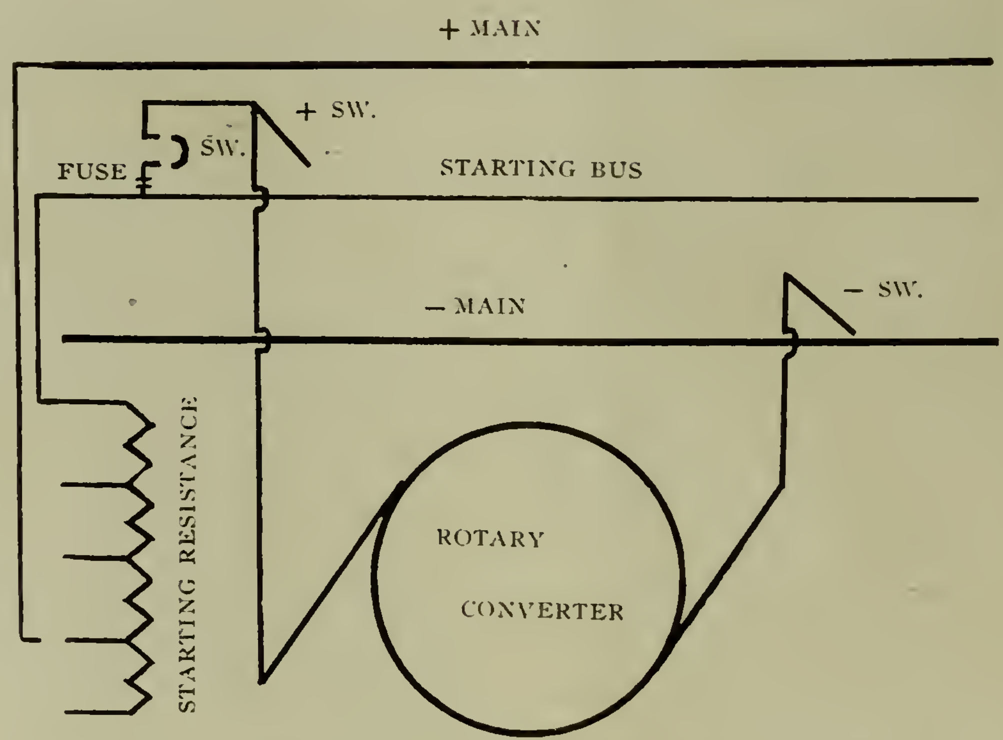

FIG. 1.—DIAGRAM OF ROTARY-CONVERTER DIRECT-CURRENT STARTING CIRCUIT, SHOWING THE STARTING RESISTANCE BY WHICH THE SPEED MAY BE REGULATED FOR SYNCHRONIZING, THE FIELD RHEOSTAT BEING ENTIRELY CUT OUT AT STARTING TO GIVE THE GREATEST POSSIBLE TORQUE, CONSEQUENTLY THE SPEED CANNOT BE REDUCED BY THE USUAL WAY OF STRENGTHENING THE FIELDS

the load, until the converters are again synchronized. Fig. 2 is a diagram of the connections between the alternating-current and direct-current systems.

There is always the possibility, however, of trouble on the generating units or supply system so serious as to cause a total shut-down of the sub-stations for a period sufficient to fully discharge the sub-station accumulators. Should an interruption of this nature occur during the time of the system peak, such a result would inevitably follow. Operating regulations require that the accumulators be withdrawn from the service system, when, with all end cells in circuit, the voltage falls to 75 volts per side. Whether this requirement could be successfully met has not been determined in practice.

If the storage batteries were fully discharged, leaving the entire direct-current system dead, it would be difficult, if not impossible, to synchronize the converters. Although it is possible to start machines of 1000-KW. capacity with a very small difference of potential, and any converter will continue to rotate when left connected to a live bus, with a low voltage on the direct-current bus the difference of alternating-current potential between the high-tension bus and the primary of the transformer will be so great that an attempt to synchronize rotary converters under such conditions is apt to cause disastrous consequences. The protective devices are likely to disconnect the converters from the supply mains, and if these devices are rendered inoperative there is extreme danger of injuring or wrecking the induction regulator, or causing an excessive rush of current that may seriously lower the line voltage.

However, if the rotary converters can be brought to synchronous speed and the moment of synchronism be clearly indicated by the use of special low-voltage lamps, the oil switch may be closed with the converter, regulator, and transformer in phase with the generator, and there would be no twisting or straining effect on the regulator, as is present when the switch is closed out of synchronism. In this case the danger would be materially lessened, but there would still be an objectionable rush of current when a difference of 6000 or 8000 volts existed between the alternating-current bus and the primaries of the transformer. The high voltage of the line would tend to instantly raise the secondary system to the same relative potential, and this could not be done without an excessive flow of current from the generators at the central station.

If the batteries were withdrawn in time to insure their usefulness in synchronizing the rotary converters, the connected load in the business district of the city is so great during the system peak that it would be quite impossible to pick up this load unless the entire capacity of all the sub-stations involved was thrown on the service mains simultaneously, a thing that would be impracticable. This may be readily understood when it is remembered that the tendency of direct current is to flow toward every part of the system where there are closed circuits, and the direct-current mains being all interconnected, the sub-station which first connected its converters to the service system would tend to supply current to the entire system. During the day and the early hours of the evening the amount of current consumed in the downtown section of Chicago is enormous, reaching many thousand kilowatts, while no single converter sub-station has a capacity of more than 6000 KW. at its overload rating.

Rotary converters may also be started as induction motors from the high-tension supply mains when the transformers are provided with half-tap secondary windings, which reduce the voltage of the starting current to one-half the ordinary pressure. One converter may be started in this manner as soon as the 9000-volt line is alive at normal voltage. By connecting it to an idle bus the remaining

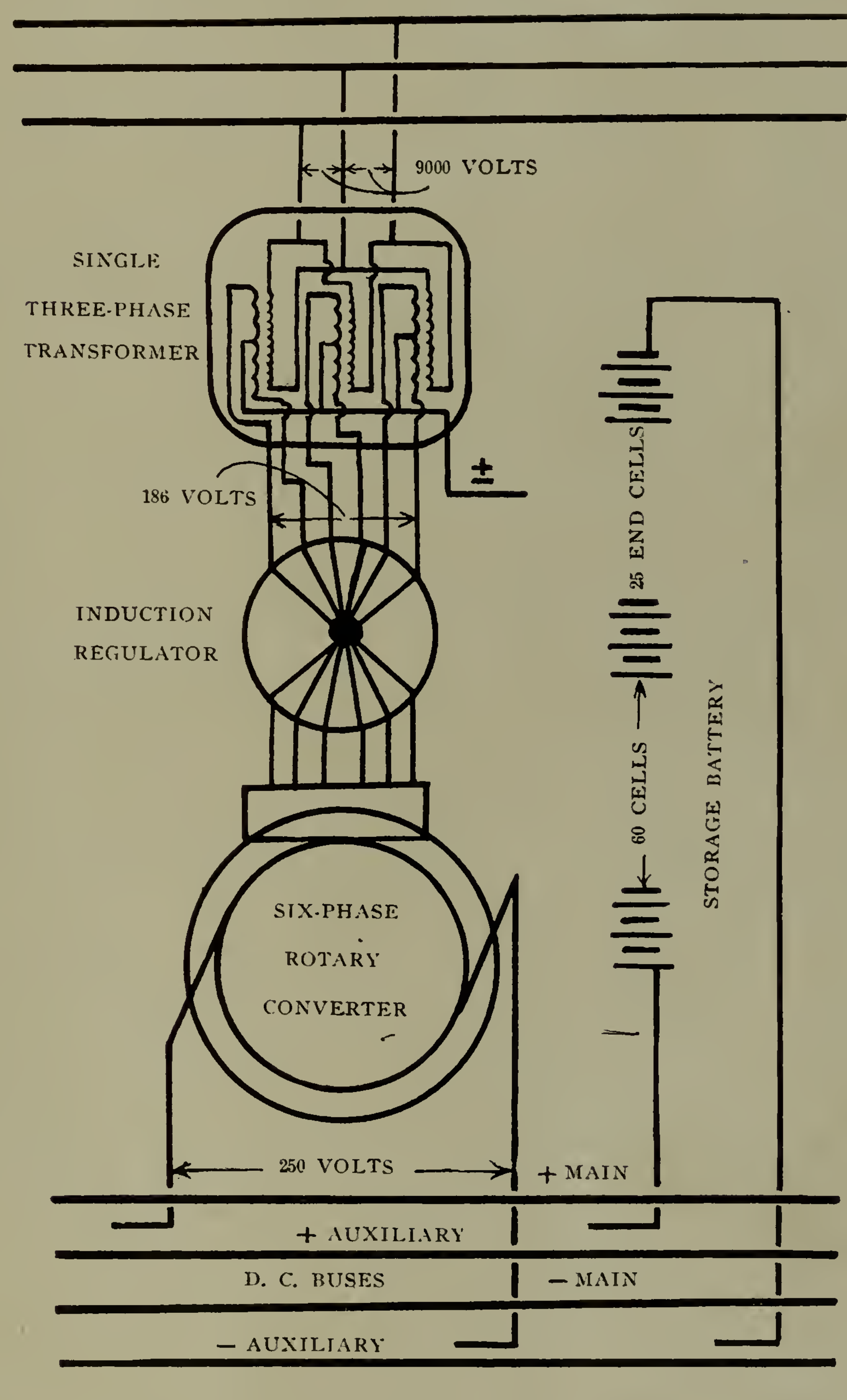

FIG. 2.—DIAGRAM OF CONNECTIONS BETWEEN THE ALTERNATING-CURRENT AND DIRECT-CURRENT SYSTEMS

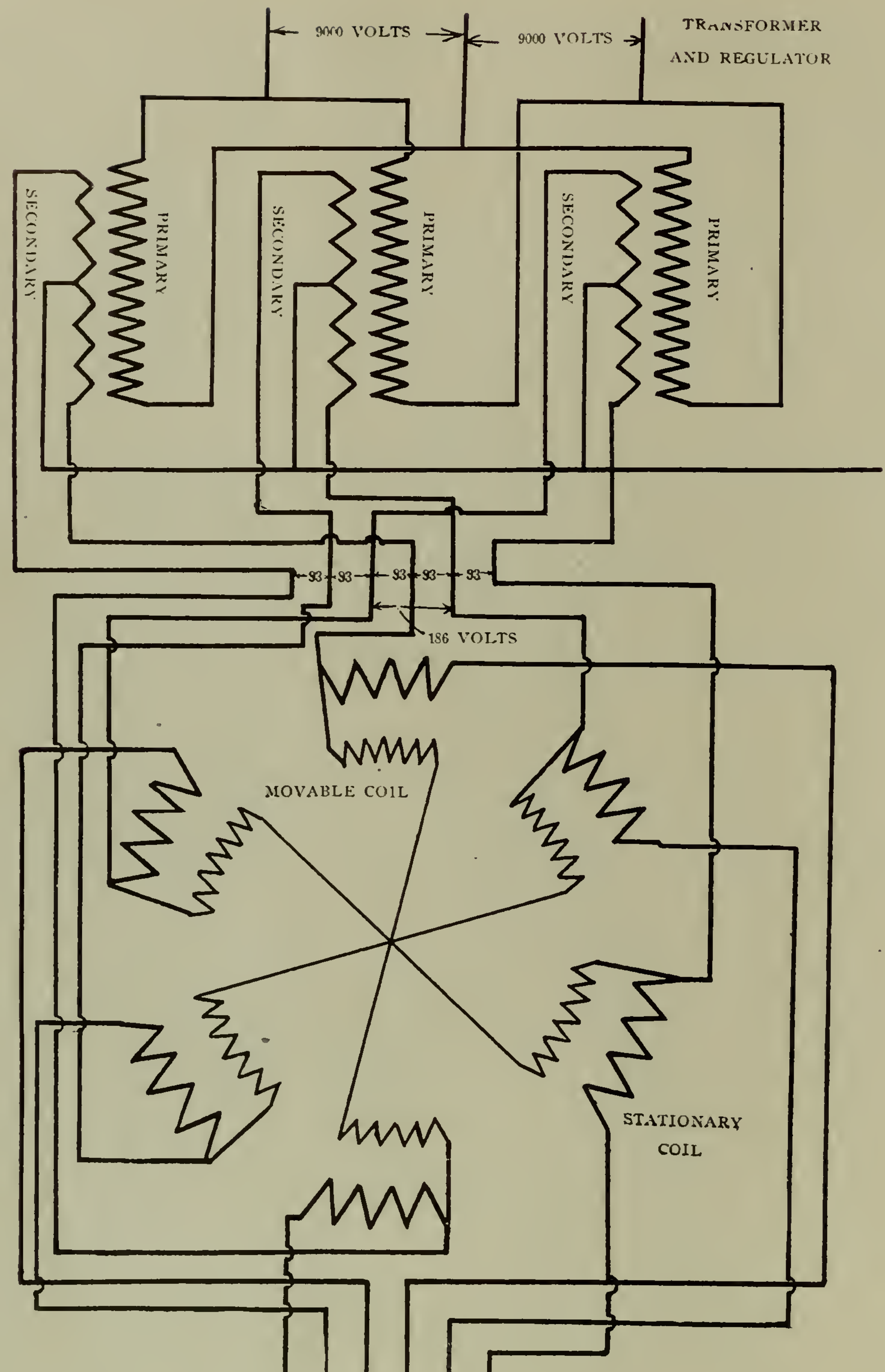

FIG. 3.—DIAGRAM SHOWING THE WINDINGS OF THE TRANSFORMERS AND INDUCTION REGULATOR. THE MOVABLE COIL OF THE REGULATOR IS OPERATED BY A SMALL INDUCTION MOTOR, AND SERVES EITHER TO BOOST OR CHOKE THE TRANSFORMER VOLTAGE.

converters may be started in the usual way and synchronized. A number of the sub-stations of the Chicago Edison Company are equipped with converters of this type, to be started from the alternating-current end in case of need. The difficulty of picking up the connected load, however, is encountered with this method, as under former conditions. To successfully meet the requirements of an emergency of this nature is the purpose of the new method of starting converters from rest which was recently tested.

Rotary converters may be started from rest by multiphase alternating currents of low frequency and potential received from a turbo-generator, which is also started from rest and gradually accelerated in speed, because of the characteristics of the six-phase converter. As the multiphase alternating currents circulate in the armature, a rotating magnetic field is induced in a plane normal to the axis. Heavy currents are induced in the field winding by this magnetic field, and the magnetic field induced by these currents reacts on the armature field and causes the armature to rotate in a direction opposite to that of the rotating field.

To start converters with multiphase currents and by stages of gradual acceleration raise the service system in this way, it is necessary to have one or more converters in each sub-station connected through the transformer to the high-tension bus by closing the oil switch. One or two transmission lines to the generating station are closed and connected to a turbo-generator which is to be started from rest. As shown in Fig. 4, the converter direct-current switches, including the quick-break and selector field switches, should be open, and the field circuits disconnected from the discharge resistances during the period of starting. The direct-current brushes on the rotary converter should be set opposite the centre of the pole pieces, the entire field rheostat should be cut out to give the greatest possible starting torque and the potential regulators placed in the neutral position.

When preparatory operations are completed by the various sub-stations, the generator at the central station is started with fields strongly excited. The moment the turbine begins to revolve a direct-current voltmeter connected across the terminals of a rotary converter will indicate the fact by an oscillatory movement of the pointer. As the speed and frequency of the turbine increases, the oscillation of the pointer becomes more marked and rapid, and, within one minute after the first indications on the voltmeter, the converter armature will turn over. The moment it revolves freely the converter direct-current switches should be closed to an idle bus. The voltmeter must be observed at this point, to determine the polarity of all the converters started. If the polarity of any machine is not correct, positive to positive, and negative to negative, it must be corrected, after which all of the converters running may be connected to the same bus.

Other converters may now be started in the same manner and synchronized. If the speed of the converters to be synchronized is too high, synchronous speed may be obtained by increasing the sections of resistance in the starting circuit, shown in Fig. 1. The same effect is produced, though in a lesser degree, by weakening the fields and shifting the brushes backward on the converters. Synchronizing at the low voltage and frequency at which the generator is running is likely to be difficult, but by using special low-voltage lamps the moment of synchronism is very clearly indicated. While reasonable care should be exercised, it is safe, with a line voltage below 4000 volts, to synchronize under conditions that would be hazardous at normal high voltage.

The time required to complete all necessary starting and synchronizing operations will depend largely on conditions and cannot be definitely fixed. When only one converter is started from rest and another synchronized, all operations should be completed in two minutes after the first converter turns over.

When the number of converters started from rest or synchronized at the low potential and frequency is of sufficient capacity to carry the system load, and after their voltage equals or exceeds that of the service mains, they should be connected to the system. Additional generators at the central station will be started and synchronized with the one now running at the low frequency and potential, until the necessary capacity is available for raising the system voltage to normal and completely restoring the service. When this is done, acceleration begins, and is continued until a normal high voltage and frequency are reached, when the sub-stations should have picked up and be carrying the system load, without shock or strain to any part of the apparatus. This is the special advantage of this measure of starting, and the experiments which were recently carried on by the Chicago Edison Company fully demonstrated its practicability. No serious difficulties were encountered, and the results were entirely satisfactory.

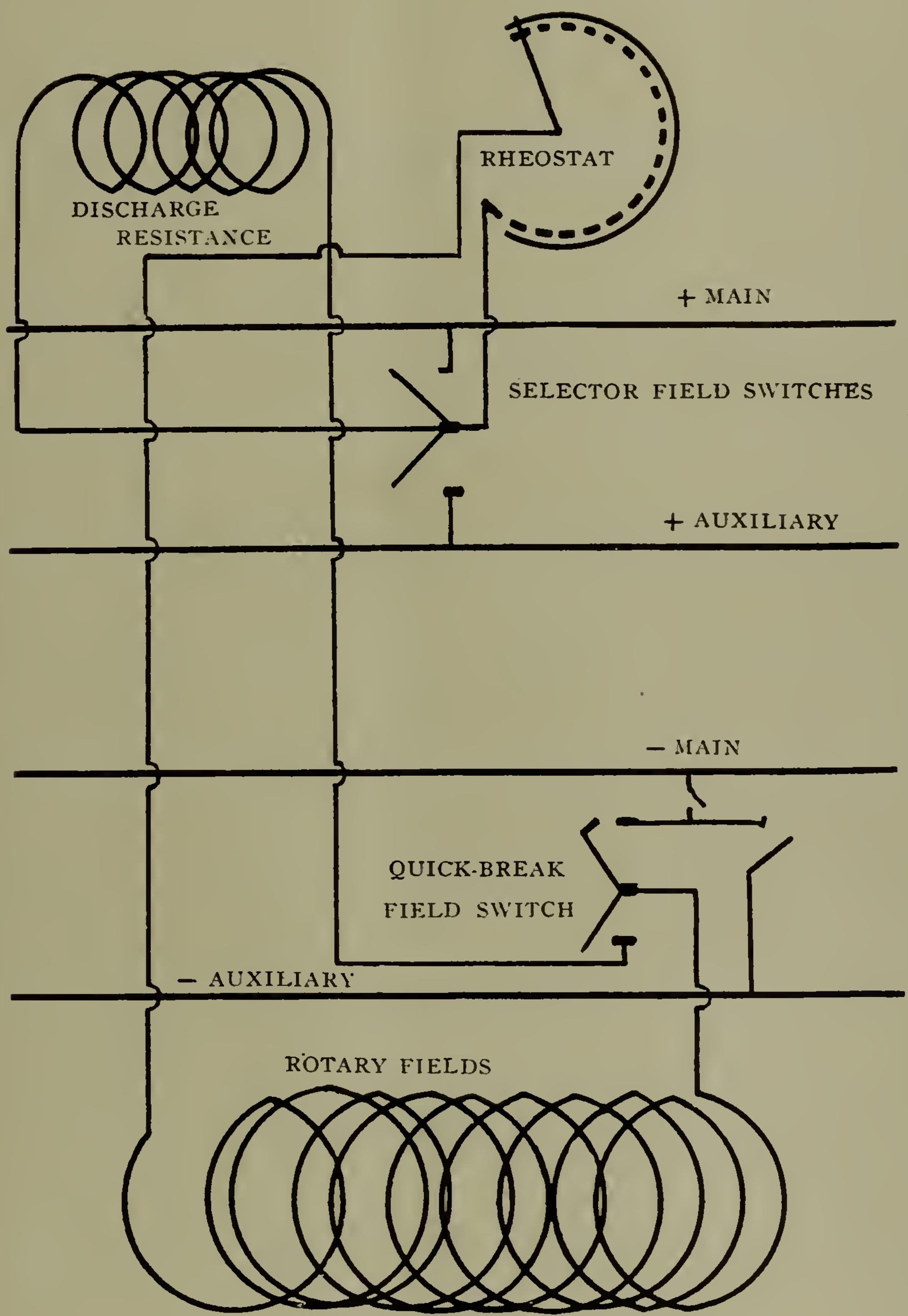

FIG. 4.—DIAGRAM OF CONNECTIONS OF THE ROTARY-CONVERTER FIELDS. THE SELECTOR FIELD SWITCHES ARE TO PERMIT SYSTEM OR SELF-EXCITATION FROM EITHER THE MAIN OR AUXILIARY BUS BARS. THE QUICK-BREAK FIELD SWITCH IS FOR BREAKING THE FIELD CIRCUIT IN SERIES WITH A DISCHARGE RESISTANCE TO PREVENT THE HIGH INDUCED E. M. F. IN THE FIELD COILS FROM PUNCTURING THE INSULATION

In the first of these tests, converters in eight sub-stations, with a total capacity of 11,000 KW., were started primarily by the turbine, or subsequently synchronized. In the second test other sub-stations were included, and converters with a total capacity of 18,000 KW. were started or synchronized. In the remaining tests, converters and motor-generators with a capacity of 27,000 KW. were driven by one turbo-generator of 6000 KW. at the central station. In each test the turbine was accelerated until the line pressure reached a normal of 9000 volts. No difficulty was experienced in operating the turbine, the speed being successfully controlled in each test.

Some time after these tests others were made on a more extended scale, and various modifications and improvements suggested by the experience of the first were embodied in the operating regulations and put into practice. In this second series of tests thirteen sub-stations were included, in each of which one converter was started from rest and one synchronized, the twenty-six converters thus started having a total capacity of approximately 20,000 KW. In all, five separate tests were made. In the last two tests the time for synchronizing was limited, and acceleration began much sooner than in the previous ones.

At the White City sub-station two 1000-KW. machines were connected to the service system in each test, and picked up the entire White City load. This feature of the experiment was of special interest and importance, as it involved all of the conditions of emergency operating, and its successful completion was a practical demonstration of the utility of the method of starting converters from rest.

In the greater number of sub-stations system excitation was used in the first test and self-excitation in the remaining ones. The advantage of system excitation lies in the fact that the polarity of the converters must be right when the converter fields are system-excited, thus saving the time necessary to correct polarity should it come up reversed. In the case of a total shut-down, when the entire direct-current system was dead, system excitation would be impossible, but the storage batteries could be used for this purpose, for, although fully discharged, they would have recovered sufficiently on being withdrawn from the system to furnish current for field excitation for the purpose of correcting polarity.

Practically all the sub-stations engaged in the experiments completed their synchronizing operations in each test in good time. In a number of instances remarkably quick work was done, all synchronizing operations being completed and reported to the load dispatcher in thirty seconds. Altogether, the results indicate the high standard of operating efficiency which is maintained by the operating department of the Chicago Edison Company.

Undeveloped Water Powers in New York State

By WALLACE C. JOHNSON

Some months ago the author made a survey of the Adirondack watershed in New York State to determine the possibility of utilizing the numerous water powers for electric power generation. The conclusions drawn from this survey are embodied in this article, prepared shortly before his death. What he tells about them should convince those who are fearful of encroachments upon the scenic beauty of the region that the development of these powers would add to the attractiveness and healthfulness of the place for summer camping, while also aiding greatly in the industrial progress of the State.—The Editor.

THE progress of the art of developing and using power makes the present as favourable to the use of power generated by the water-fall as by any other method. That being the case, it would certainly seem that our water-power resources should be carefully conserved. There is no country in the world which so abounds in water-power opportunities as does this country, and no part of this country is so supplied with this valuable resource as is the State of New York.

To mention but one section: To the north and east in the State is a tract of land over 11,000 square miles in extant, lying at an elevation of more than 800 feet above sea level. The rivers which flow from this great tract toward the north come down to an elevation of approximately 150 feet above sea level before emptying into the St. Lawrence River. Rivers flowing to the east come down to an elevation of about 100 feet above sea level before entering Lake Champlain. Rivers flowing to the west and south come down to even a lower elevation, so that we may say that all the water leaving this great tract of land falls an average of 700 feet within a comparatively short distance.

This elevated region is sparsely inhabited. A very large proportion of it is covered with a wild growth of trees, brush and the like. It is the expressed intention of the State to become the owner of practically all of this great tract of land, and to withdraw it from settlement and agriculture. A large percentage of it has already become the property of the State.

By reason of the mountainous character of the land making up this widerness tract, the rivers which flow out of it are subject to floods at certain seasons of the year, and discharge vast quantities of water, bringing down silt to form bars in navigable rivers, flooding the lands through which they flow, inundating cities and towns, and doing damage every year to the extent of hundreds of thousands of dollars. At other seasons of the year their flow becomes so small that they are practically useless for any commercial purpose.

On practically all these rivers there is opportunity to create reservoirs by which the waters of the floods would be held back, and by which the flow of the rivers could be regulated. By the building of such reservoirs, the damage now caused by the floods would be greatly reduced or wholly removed. The level of the upper Hudson, for example, could be maintained at a point about 2 feet higher than it now is, and on through the summer season, thus aiding navigation and saving large sums of money which will otherwise necessarily be expended in dredging in order to provide for the increasing traffic on the river.

If sufficient reservoirs were created to completely regulate the flow of the rivers, making it practically uniform throughout the year, upward of one million horse-power could be developed, whereas now the flow of the rivers is so low that comparatively little use is made of them for the purpose of generating power. These power stations would naturally be outside the wildnerness, and would be so located that power from them could be distributed to any point in the State.

It is not, however, the only portion of the State in which such work might profitably be done. If the rivers of the State were conserved, and used for power, as they would be, very many millions of dollars now paid by the citizens of New York State to the citizens of other States for coal and for power purposes would be saved every year. In the place of this vast annual expenditure for a perishable commodity we would have investments within our own borders in permanent works, adding to the real value of the property. Proper returns on these investments would be provided for by saving the money now spent annually for coal.

New York State is one of the few that did not early in its history encourage by legislation the conserving of its rivers. Practically the only storage of water which has been undertaken is that done by the lumbering interests. People engaged in lumbering have been in the habit of building dams at the head waters of the streams, usually utilizing some small lake, and the contents of the storage reservoirs so created have been thrown out, while the waters in the streams are naturally at their highest point, giving an added flow to the small streams by means of which logs could be flooded out of the upper reaches into the larger portion of the streams.

This is perhaps why people having a superficial knowledge of the subject, and on some slight acquaintance with the Adirondack region appear to conclude that the creation of storage reservoirs for the regulation of the flow of rivers means the damming of the outlets and the raising of the surface of the small lakes which are found at the head of many of the rivers in that region.

Recently many newspapers in the State have been induced to publish an item beginning: "People who make the Adirondack region their favorite camping land will do well to consider the plans, etc." The writer of this article goes on to say that certain people for their own purposes are desirous of building storage reservoirs, and he proceeds to enumerate a list of the small lakes in the Adirondacks which it is proposed, as he says, to utilize as storage reservoirs, and thereby destroy their beauty, etc. The first water mentioned in this list is the Fulton chain of lakes.

It is true that the lakes of this chain are among the most beautiful lakes in the woods, and are very much frequented, but the writer of the article in question evidently does not know that the Fulton chain is a reservoir created by the State many years ago for the purpose of feeding the Black River canal, and but for the fact that a dam was built creating a reservoir, the Fulton chain would not exist. The smaller lakes at the heads of the various rivers are practically useless as sites for storage reservoirs designed for the regulation of streams, from the fact that they are so located that they have a small drainage area, and the storage of the water, which naturally passes through these small lakes, would have very small effect upon the flow of the streams of which they are the source.

It is necessary that the regulation reservoirs be established farther down the streams above which the larger part of the drainage area lies. Along practically all of the rivers are various low-lying lands or swamps which could be flooded and used as storage reservoirs to the very great scenic advantage of the country surrounding them.

The laying out and improving of some of the best of the great private parks which have been established in the Adirondack section has involved the creation of numerous lakes for the sole purpose of beautifying the tract. The writer of the article above quoted goes on to say that if the storage of water is permitted, from 15 to 20 per cent. of the Adirondack land area would be overflowed. The writer personally examined every important stream in the Adirondack area, and has made careful calculations as to the land which would be required to be flooded in order to fully and completely regulate the flow of the various streams, and it is his estimate that less than 5 per cent. of the land area of the Adirondacks would be required for such regulation.

The creation of lakes in place of existing low lands and swamps would greatly improve surrounding conditions. They would in all cases be filled by the melting snow and rains which occur during the latter part of March and during the month of April up into the month of May. As the stream flow is, as a rule, up to the average during the early part of the summer, the reservoir lakes would be allowed to remain full. The latter part of the summer they would naturally be partially emptied, and would be filled again during the fall rains. The lowest flow of the streams issuing from these high altitudes usually occurs during January and February, when all the small brooks are frozen. It is during this period that a proper management of the reservoirs would call for their being practically emptied so as to be ready to receive the flood waters of the following spring.

During the season when the woods are most frequented the lakes would therefore be full, and add most to the beauty of the region. During the time when they were empty or practically so, that is, in the latter part of the winter, during the month of February or the first part of March, the woods are not greatly frequented. We are all fond of the woods. Some of us are unable to spend the summer enjoying their cool beauty, but we are glad that they are there. Eleven thousand square miles,—7,000,000 acres,—are a large tract for New York State to withdraw from settlement and say that it should remain a wilderness. Yet that has been done, and it has met the uniform approval of citizens of the State. It does seem, however, that if this great tract can, in addition to being used as a pleasure ground, be also used in such a way as to confer some commercial benefit upon the State it would be the part of wisdom to permit it to be so used, provided such use did not interfere with the main purpose of the State in its establishment as a park.

The location of reservoirs from which the flow of streams could be regulated would seem then to be the one purpose for which this tract could be used, and at the same time increase its desirability as a park. As has been said before, the points at which it is most desirable to establish storage reservoirs are usually swamps and low lands, undesirable for camping purposes. This area would be entirely cleared of growth before being filled with water, and the shores would at once become the same as the shores of any natural lake.

The structures that would be built for impounding the waters would be of such a character that they would not intrude upon the landscape, and there would be no evidence, except at one particular point where the dam was built, that these lakes were not natural lakes. The low and marshy places being flooded, the entire shores would be dry, and therefore desirable sites for camping purposes, and the commercial benefits conferred thereby upon the whole people of the State of New York are almost too large to estimate.

Electric Signs in New York

As an instance of what may be done by a central station to increase the number of electric signs on its circuits, the results of an aggressive campaign carried on by the United Electric Light & Power Company in New York City will be of interest. Many of the small signs in this company's circuits are installed free, the contract calling for a monthly guarantee. These free signs are of two kinds, the panel type and the raised letter type. The panel type is supplied in two different forms, one like that shown in Fig. 1 and the other, a more recent type, shown in Fig. 2. The raised letter sign is shown in Fig. 3.

The contract for the free panel sign calls for a monthly guarantee of $3, the consumption above that being charged for at 10 cents per KW.-hour. In the case of the raised letter sign, the guarantee is figured on the basis of three hours' use per lamp for twenty-five nights per month. Thus the larger a sign, the greater the monthly guarantee. For example, a customer having a four-letter sign with forty-eight 8-candle-power lamps must guarantee $12.60 per month, while with a five-letter sign with sixty-two 8-candle-power lamps, the monthly guarantee would be $13.02. Where the sign is equipped with 16-candle-power lamps, the minimum is correspondingly increased. The customer, therefore, pays in direct proportion to the value of the sign as an advertising medium.

The company has now on its circuits 409 signs of both panel types and 75 of the raised letter type, making a total of 484.

The retail lighting contract under which these free signs are installed is that used for ordinary lighting installations. A "rider" is inserted, however, with a blank to be filled in with the amount of the monthly guarantee.

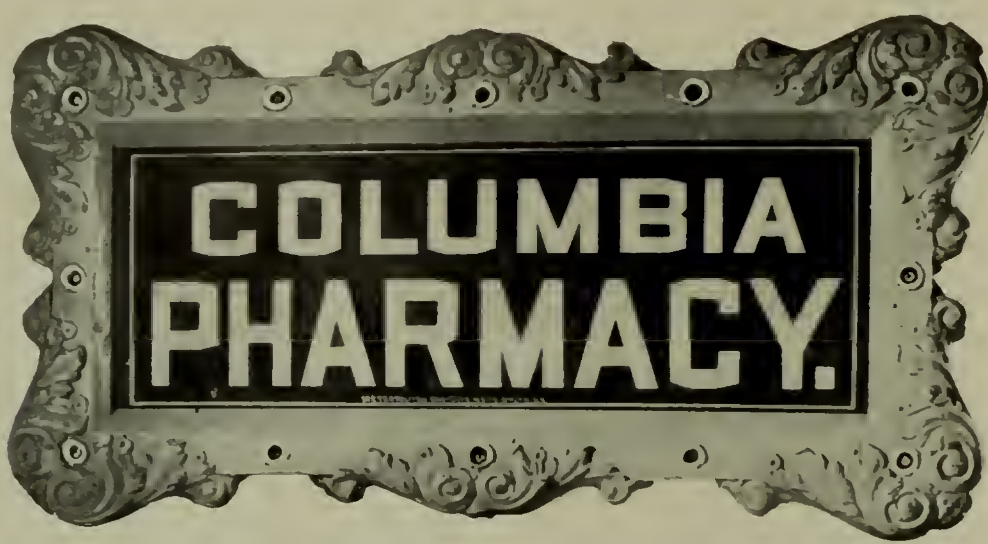

FIG. 1.—A PANEL SIGN INSTALLED FREE ON A MONTHLY GUARANTEE PLAN. MADE BY THE METROPOLITAN ENGINEERING COMPANY, OF NEW YORK

FIG. 3.—A RAISED LETTER SIGN MADE BY THE METROPOLITAN ENGINEERING COMPANY

FIG. 2.—ANOTHER TYPE OF PANEL SIGN WHICH IS INSTALLED FREE ON A MONTHLY GUARANTEE PLAN. MADE BY THE O. J. GUDE COMPANY, OF NEW YORK

Other lighting contracts, calling for larger consumption, provide for a wholesale scale of rates. When the customer makes his own lamp renewals under these wholesale contracts, a discount of one cent per kilowatt-hour is made from the monthly bill, amounting to approximately 10 per cent.

In the "wholesale A" contract, the customer agrees that during ten months of each year the monthly use of current shall not be less than 2000 kilowatt-hours, and that during such months the daily average use of the total equipment shall be not less than two hours; for the first four hours' average daily use of the total equipment 10 cents per kilowatt-hour is charged.

For all excess above four hours'

FIG. 4.—AN ATTRACTIVE ELECTRIC SIGN OF THE UNITED ELECTRIC LIGHT & POWER COMPANY IN HARLEM

average daily use, 5 cents per kilowatt-hour is charged.

A discount of 5 per cent. is made when the monthly bills reach $500, and of 10 per cent. when $1000, if paid within ten days after presentation.

In the "wholesale B" contract, the customer agrees to use 2500 kilowatt-hours monthly. The rate is 10 cents per kilowatt-hour, with the following discounts:—

For four hours or more average use daily,, 1 cent per kilowatt-hour, or 10 per cent.

For six hours or more average use daily, 2 cents per kilowatt-hour, or 20 per cent.

For eight hours or more average use daily, 3 cents per kilowatt-hour, or 30 per cent.

Should the aggregate use of current amount to 5000 kilowatt-hours monthly, an additional discount is made of ½ cent per kilowatt-hour, equalling 5 per cent., and for 10,000 kilowatt-hours monthly, 1 cent per kilowatt-hour, equalling 10 per cent.

A third contract is for very large installations, and is called the "Plant Contract."

The United Company also supplies current to the Federal Electric Sign System for numerous panel and raised-letter signs. The Federal System, in turn, rents the sign with illumination to its customers, making contracts on an hourly basis. A patrol turns the lights on and off.

Such large signs as that of the familiar "Gold Seal Champagne," with 289 2-candle-power lamps, a total of 10.6 KW.; the "Budweiser" sign, with 7.15 KW.; "El Bart Dry Gin," "Red Raven," "Victor Talking Machines," and numerous "Levey" signs, are supplied with current by the United Company at regular rates to the advertising agency, who, in turn, rent the sign to the advertiser.

The company has also recently added to its mains another large "Budweiser" sign at Park avenue and One Hundred and Twenty-fifth street. This is the largest sign in Harlem, and it attracts a great deal of attention.

It will be of interest in connection with this to give some particulars of some of the methods the company has adopted to get new business and retain the old.

Last August a neat note-book, of a size convenient for the vest pocket, was given to each employee. Inside the cover is printed the following:—

"UNITED WE STAND."

DEAR SIR:—In the belief that you are interested in the growth and welfare of our company, you are asked to carry this book with you on all occasions, and jot down anything that you see throughout the city of New York of interest to the company, either in the way of possible new business or defective service, or any other suggestions with regard to development.

It is hoped that you will take an interest in this matter and try and turn in at least one leaf daily from this book.

THE UNITED ELECTRIC LIGHT &
POWER COMPANY.

The book is provided with a metal slide in which the blank pad may be fastened and renewed from time to time. Each leaf is perforated so that it may be easily torn off, and at the top is a space for the date, name and address, followed by the remarks of the observer. The success of this plan is indicated by the following results obtained up to January 1:—

Projects, 784.

Complaints, 198.

New customers, 97.

Number of 16-candle-power lamps secured, 1985.

Increase of revenue a year, $5000.

The complaints are the notifications by the daily leaflets that an arc-lamp globe is broken, or something similar, the straightening out of which helps to maintain the service at a high standard. This method

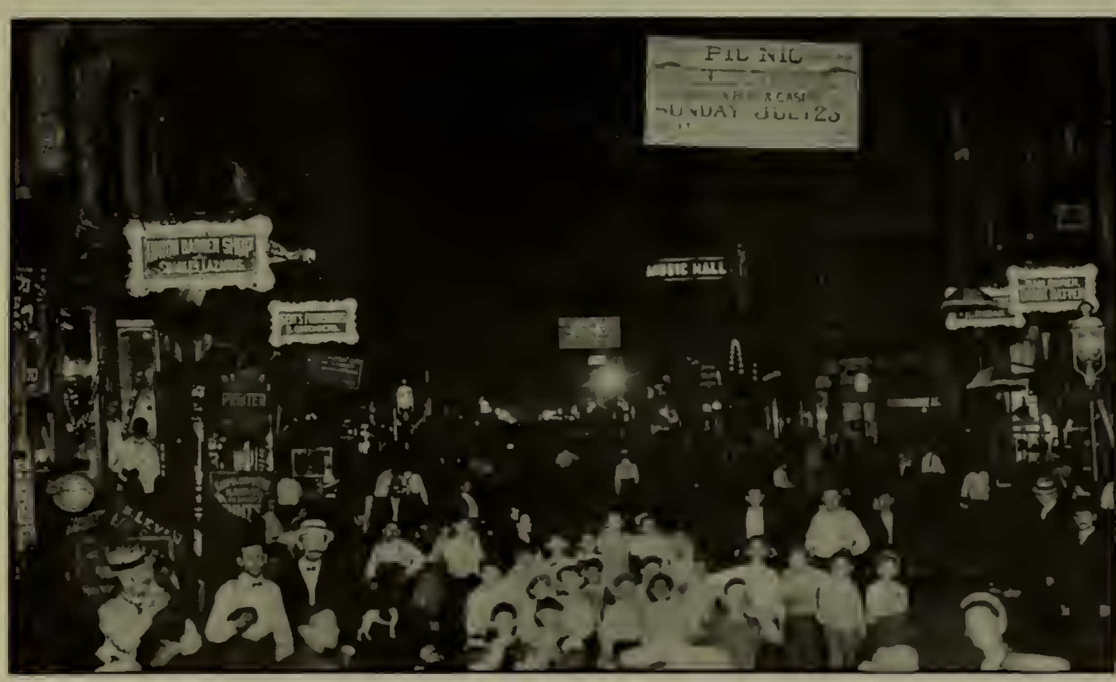

FIG. 5.—THE EAST SIDERS USE A NUMBER OF PANEL SIGNS, AS THE ILLUSTRATION SHOWS

has also proved of value in detecting theft of current. In one instance a bookkeeper noticed that lights were burning in a building which he did not have on his books.

An apartment house campaign, started in February last year, has also been productive of interesting results. Of the 332 houses to which efforts were directed, all were equipped for electric light service. Two letters were sent out, the second after the lapse of a month. The first letter was as follows:—

FIRST FOLLOW-UP LETTER

"You are not using electricity for the illumination of your apartment at the above address.

"We beg to call attention to the fact that under the present scale of rate, 10 cents per kilowatt-hour (equivalent to ½ cent per lamp-hour), the cost of electric lighting is greatly reduced.

A FAMILIAR SIGN ON UPPER BROADWAY

ANOTHER OF THE LARGE ATTRACTIVE SIGNS WHICH HAVE HELPED TO MAKE BROADWAY "THE GREAT WHITE WAY"

"The apartment which you occupy is equipped for service, it being necessary only to place a meter and the required incandescent lamps. This is done by and at the expense of the company. We make no minimum charge; you pay only for the actual use of light, as recorded by the meter.

"The introduction of electric service will put at your disposal the use of electric fans and many other modern conveniences, such as cooking appliances, electric flat irons, curlers, heaters, etc. This company has at its general office an interesting exhibit of electric heating and cooking appliances, where they are on sale and may be seen in operation.

"The receipt of enclosed postal card will serve to bring our representative to you for further information."

The postal card referred to was printed in blank, the prospective customer filling in the time at which it was desired to have the representative call.

The second letter was as follows:—

SECOND FOLLOW-UP LETTER

"Last month we wrote you on the subject of using electric light in the apartment which you occupy and which is equipped for service. Perhaps the letter did not reach its destination, or was not in full enough detail. May we not send our representative to furnish you with facts and figures concerning this question?

"Assuming your apartment to be equipped with fourteen incandescent lamps, burning all of these lamps, if full 16-candle-power each, an average of one hour daily for thirty days would cost less than $3 for the month's supply. The lamps are furnished and renewed by this company without charge. No deposit required upon furnishing satisfactory reference. Meter placed and service put at your disposal the day following receipt of application.

"Why not make an experimental trial of electricity? If the results are not satisfactory there is no obligation on your part to continue its use."

The results obtained from this campaign may be summarized as follows:—

	Feb. 24, 1906.	May 1, 1906.
Houses	332	332
Tenants	6,373	6,373
Tenants using	4,003	4,225
Tenants not using	2,370	2,148
Per cent using	62	66
100 per cent houses	37	74
75 per cent houses	124	136
50 per cent houses	86	71
Under 50 per cent	85	51

The last four items perhaps require some explanation. By 100 per cent. houses are meant those in which all the tenants are using the service; by 75 per cent., those in which 75 per cent. are using the service, and so on. It will thus be seen that the campaign reduced the number of houses in which the per cent. of users was low and increased the number in which the per cent. of users was high.

Projected buildings are also closely followed up. The reports in the building trade journals are gone over, and a card is made out, giving the location, description, cost and the names of the owner and the architect. An original is kept in file at the company's office, a duplicate being given to the agent who follows the matter up. Spaces are also provided on the card to enter the name of the party to whom the agent is referred and the final disposition. This method has added over 1000 KW. to the company's mains within the past year.

Calculating the Performance of an Economizer

IN many plants the reduction of the fuel consumption by a small percentage will effect a large saving in the yearly operating cost, and the question of the advisability of installing an economizer to effect this saving is thus an important one. The following method of calculating the performance of an economizer and the reduction in operating cost will, therefore, be of interest.

Let us take as an example a plant of 8000-KW. rated capacity, the load being carried by two turbo-generators, one 3000 KW. and the other 5000 KW. At the time of peak load these generators must carry a maximum of 10,000 KW., or an overload of 25 per cent.

The distribution of the load during the day is assumed as in the curve given herewith. Thus the load from midnight to 6 A. M. would be 1000 KW., from 6 to 8 A. M. 4400 KW., from 8 A. M. to 5 P. M. 3100 KW., from 5 to 8 P. M. 8000 KW., and from 8 P. M. to midnight 2000 KW.

Suppose the boilers to be arranged in two batteries of five boilers each, all supplying steam to a common main which is connected to both turbines. An economizer is to be provided for each battery, or two for the entire plant. The boiler pressure is 200 pounds.

The formula used in calculating the performance of the economizer is as follows:—

$$X = \frac{Y}{\frac{30}{\alpha} + \frac{5W + GC}{2GC}Y}(T - t)$$

X is the rise of temperature of the feed-water in the economizer.

Y is the number of square feet of economizer heating surface provided per boiler horse-power developed at any time; hence it varies for different periods of the day.

α is the coefficient of absorption for the economizer. Different values of α are taken for different rates of working, from 3 for heavy loads to 2 for a light load, such as is carried at night.

C represents the amount of coal burned; in this discussion it is taken as unity, the values of the quantities W and G being reduced to the same basis.

W is the amount of water fed to the boilers, and is assumed as nine pounds per pound of coal.

G is the amount of air supplied for combustion per pound of coal; it is here taken as 22 pounds.

T is the initial temperature of gases entering the economizer, and depends on the rate at which the boilers are working. Different values are, therefore, assumed for the different rates of working

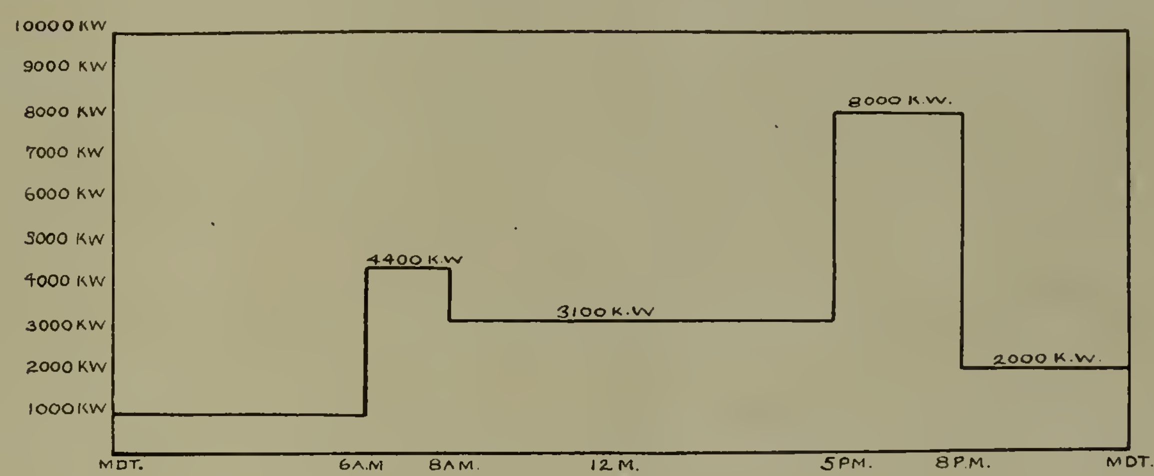

DIAGRAM SHOWING THE ASSUMED LOAD AT DIFFERENT PERIODS OF THE DAY AND NIGHT

t is the initial temperature of the water entering the economizer, and will probably lie between 150 degrees F. and 200 degrees F. Both these figures are used as a basis of calculation.

The formula reduces to:—

$$x = \frac{Y}{\frac{30}{\alpha} + 1.5Y}(T - t)$$

Under the given load conditions the operation of the plant would be about as follows:—

Midnight to 6 A. M. Load carried by 3000-KW. unit. One battery of boilers in service with one economizer.

6 A. M. to 8 A. M. Both generators, both batteries of boilers, and both economizers in service.

8 A. M. to 5 P. M. Load carried by 5000-KW. generator. Both batteries of boilers and both economizers in service.

5 P. M. to 8 P. M. Both generators, both batteries of boilers, and both economizers in service.

8 P. M. to midnight. Load carried by 3000-KW. generator. One battery of boilers with one economizer in service.

For the average load of 3100 KW. during the twenty-four hours, let us assume 5 square feet per boiler horse-power for the heating surface of the economizers. Assuming a steam consumption of 20 pounds per kilowatt-hour, the boiler horse-power corresponding to the average load would be 2067, on the basis of 30 pounds of steam per boiler horse-power. The total heating surface required for the two economizers would then be 10,335 square feet.

For the different periods, then, with the values of Y and α as given below, the values of X are calculated by the formula.

Midnight to 6 A.M.	$Y = 7.75$	$\alpha = 2.0$	$X = .29\ (T - t)$
6 A.M. to 8 A.M.	3.52	3.0	.23 "
8 A.M. to 5 P.M.	5.0	2.25	.24 "
5 P.M. to 8 P.M.	1.94	3.0	.15 "
8 P.M. to Midnight	3.87	2.75	.232 "

The assumed values T and t during the different periods and the corresponding values of X are as follows:—

T	t	X
450	150	87
550	150	92
500	150	84
575	150	64
500	150	81

To obtain the average rise in temperature of the water in the economizer, multiply the kilowatt-hours at each period by the temperature rise and divide the sum of the products by the total kilowatt-hours. The result, 78 degrees, is the average rise for twenty-four hours. We have in the foregoing assumed the initial temperature of the water entering the economizer to be 150 degrees. If we assume it to be 200 degrees, the values of X will be as follows:—

T	t	X
450	200	72
550	200	81
500	200	72
575	200	56
500	200	70

The average temperature rise of the water will, therefore, be 68 degrees.

To estimate the saving effected by a temperature use of 78 degrees, we will consider that to generate steam at 200 pounds from water at 150 degrees 1082 B. T. U. are expended, 78 B. T. U. being absorbed by the water in the economizer and the remainder, 1004, in the boiler. The per cent. of saving would, therefore, be

$$\frac{78}{1082} \times 100 = 7.2 \text{ per cent.}$$

For a rise of 68 degrees the B. T. U. expended would be 1031.5, and the per cent. of saving would be

$$\frac{68}{10.31.5} \times 100 = 6.6 \text{ per cent.}$$

As the average load is 3100 KW. and the steam consumption 20 pounds per kilowatt-hour, or 9 pounds per pound of coal, the coal burned per hour is 6889 pounds, and per year 27,000 long tons. The yearly saving with 7.2 per cent., would be 1940 long tons, which, at $3 per ton, would mean $5820. At $1.25 per square foot of heating surface, the cost of the two economizers, with a total of 10,335 square feet, would be $12,-919. Hence the return on the investment would be $5820 ÷ $12,919 = 45 per cent.

For a temperature rise of 68 degrees with a saving of 6.6 per cent., the coal saved would be 1782 long tons, valued at $5346, or 41 per cent.

The percentages of saving obtained in this way, however, do not represent the net saving, as depreciation and repairs, operation, taxes, and insurance must be considered. It will be of interest in connection with this to refer to a paper read by R. D. Tomlinson, before the New York Railroad Club, giving results of the tests on the economizer plant of the Seventy-fourth street power station of the Manhattan division of the Interborough Rapid Transit Company, of New York.

The author assumed that with fair usage and proper attention a figure of 6 per cent. per annum on first cost ought to suffice for depreciation and repairs. The other fixed charges are operation, $1\frac{1}{4}$ per cent.; insurance and taxes, $2\frac{1}{2}$ per cent., making a total of 9.75 per cent. The plant has 16 economizers of 512 tubes each, which are used with sixty-four boilers of 520 H. P. each. The cost of the economizers, each having 6760 square feet of heating surface, is assumed at $15 per tube.

The saving due to the economizers is given as follows:—

Total coal per year	180,000 tons
Coal saved per year	16,506 "
Saving at $3 per ton	$49,518
Cost of economizers	122,880
Fixed charges	11,981
Net saving	37,537
Net return	30 5 per cent

If we take the same per cent. of fixed charges for our calculations, the net return with a rise of 78 degrees would be 45—9.75 = 35.25 per cent., and with 68 degrees, 41—9.75 = 31.25 per cent., which closely approximate the figure given by Mr. Tomlinson.

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Leading Articles

The Ice Problem in Water-Power Plants

FROM the number of questions regarding the ice problem in water-power plants, in the Question Box of the National Electric Light Association, it would appear that the subject is one of great interest, and when it is considered that plants are often forced to shut down in consequence of ice choking the racking, penstocks or wheels, the importance of finding a solution of the problem is evident. The article elsewhere in this issue, then, in which the writer gives his experience with ice in several plants, together with the means of avoiding the difficulty, should prove of great value.

One of the plans in use to a very limited extent in freeing the racking of ice is in the use of hollow rack bars through which steam is circulated. However, this plan presupposes the existence of a steam generator, found, perhaps, in a reserve steam plant. If such a plant exists, the trouble may be avoided by shutting down the water plant and running by steam during the period of ice troubles. Where the trouble is in the turbine itself, the method of running a steam pipe to the top of the casing and turning on the steam for about fifteen minutes once or twice an hour also appears to have been effectual in removing ice.

The lessening of the flow of water due to the clogging of the racking by anchor ice may be avoided, to a certain extent, by removing the racks and relying on booms and continuous patrol of the forebay day and night. This method, however, has the great disadvantage, as pointed out by the author, of incurring an increased expense for the wages of the patrol.

As is well known, water is at its maximum density at 39.1 degrees F., the density decreasing above and below this temperature. Hence colder water will rise and freeze above the warmer. The formation of anchor ice has been held to be due to the mixing of the cold and warm water as it flows over falls or rapids or passes through a head race or racking at a high velocity. It has, therefore, been argued that a decrease in velocity in forebays and through racks would reduce and even eliminate the formation of anchor ice.

This conclusion, however, does not appear to be generally accepted, as in more than one instance increasing the area of the racking has not diminished the formation of anchor ice. It has, however, distributed the ice formation, and thus to a certain extent remedied the trouble, though it still made hard labour necessary in clearing the racks.

It will thus be seen that none of these methods does away with the difficulty of keeping the ice away from the racking. In the suggestions made by the author, it will be observed, the concrete aprons are employed to give clear water to the racking and thus prevent any possible clogging by the various ice formations.

Undeveloped Water-Powers in New York State

AT this time, when the question of creating reservoirs for water-power development in the Adirondacks is before the people of New York State, the article elsewhere in this issue by the late Wallace H. Johnson will be of particular interest.

The discussion thus far in the daily press seems to be mainly on the point of destroying valuable timber land by flooding with water and also taking so much more camping ground away from summer visitors.

In these days of "trust-busting" and "octopus-killing," the opponent of any measure which confers privileges on a corporation is only too apt to indulge in hysteria and stigmatize every such project as a "grab." And so in the matter of establishing reservoirs in the Adirondacks, the zeal of the guardians of the public weal has made them somewhat incapable of a judicial consideration of the question.

Solely on the point of detracting from the beauty of the region, the fears expressed appear, from Mr. Johnson's article, to be without foundation. Many of the sections in the Adirondacks have been made much more attractive by the very thing,—building reservoirs to create lakes,—which it is feared will destroy the beauty of the lands flooded.

Furthermore, as pointed out by

Mr. Johnson, existing lowlands and swamps would be flooded by the proposed plan. No one would camp in the lowlands, where the run-off from rains would flood the camp, and the lack of utility of a swamp for camping purposes, or, in fact, for any other, is unquestioned. This fact, then, disposes of the contention that the beauty of the most attractive sections would be marred by the proposed reservoirs. And when it is considered also that less than 5 per cent. of the total land area would be needed for flooding, it does not appear clear why any objection should be raised on this score.

The discussion, then, narrows down to the question:—What can be the objection to building reservoirs which will not only provide for the generation of a large amount of power, but also increase the attractiveness of sections which at present are lacking in this respect?

Starting up a Rotary-Converter System

ONE of the problems which companies having a rotary-converter system must be prepared to deal with, even if the emergency never occurs, is a total shutdown of the system. How serious a matter this would be is told by J. E. Hill elsewhere in this issue in the article dealing with the method adopted by the Chicago Edison Company.

Methods of starting up rotary-converters are varied. They may be started up from the direct-current side directly or from the alternating-current side by means of a starting motor or by impressing a reduced voltage obtained from transformer tap windings. They may also be started from a motor-generator.

Where no direct current is available, however, as in the total shutdown of the sub-stations and the total discharge of the storage batteries, and where no starting motor, motor-generator or tap windings are provided, only one method remains, and that the one described by the author, of connecting the converters through the transformers to the high-tension bus-bars, closing the lines to the central station and connecting to a turbo-generator, which is started from rest.

Each of these methods has its advantages and disadvantages. The advantage of starting from the direct-current side lies in that no investment is necessary for auxiliary apparatus. The choice between a separate starting motor and a motor generator is also largely a matter of cost, where a large number of rotary converters are installed the motor-generator having the advantage that one unit may be used in starting several converters. With the converter starting as a motor, also, the voltage builds up more quickly than when a separate starting motor drives it as a generator. The reduced voltage from tap windings also does away with the need of auxiliary apparatus, yet a difficulty is encountered, as pointed out by the author, in picking up the connected load.

The method tested by the Chicago Edison Company is not a new one, but has been tried out before. From the results detailed by the author, it would appear that it affords a solution of a very important problem.

Interesting Employees in Business Development

TO every central station manager we believe the particulars given elsewhere in this issue of some of the business-getting methods of one of the New York companies will be of no little interest.

In other lines of work the plan has been in use for some time of placing a box in a prominent place so that employees might drop in suggestions regarding the carrying on of work, or the like. The plan of the United Electric Light & Power Company for giving to each employee a note-book in which may be jotted down any information which may lead to getting new business we believe to be a unique one.

One of the great advantages of the plan is that the only expense incurred is for note-books, and that a very small one. We are not accustomed usually to get something for nothing, yet when it is considered that the information obtained from the books resulted in an increased revenue of $5000 a year, it would seem that this was the case.

However, no employee will work purely for love, and while in this particular instance nothing is offered in the way of prizes, the activity of the employee in filling his note-book with valuable suggestions is taken into consideration in the matter of an advance in salary.

Electricity as an Aid to Its Own Production and Supply

IN the February issue of the bulletin of the Edison Electric Illuminating Company, of Boston, some interesting particulars are given of the numerous ways in which electricity aids in faciitating its own production and supply. To begin with, the coal is taken from the colliers by motor-driven hoists and conveyed to the furnaces by motor-driven conveyors. In the engine room, the valves are electrically operated, the lubricating oil pumps are motor driven. Valves in the water and air pipes are also operated by electric motors.

In the repair shops, motors drive the machine tools and the forge blowers, and the soldering irons are of the electrically heated type. In the lamp department the arc-lamp carbons are cut to proper size and shape in electrically driven machines, while the globes are washed and dried by means of electricity.

Six electric wagons are used for exchanging lamps in the city and suburban districts, and electric trucks deliver supplies where needed and carry machinery, cable, and poles. The cables are drawn into the conduits with the aid of a motor-driven windlass on the truck.

In the office, an addressograph is driven by a ¼-H. P. motor, and tabulating, sorting, and adding machines, and an automatic envelope sealer are all electrically operated. Every station of the company is provided with a hot-water heater for the convenience of the employees, and electric radiators are used wherever necessary for the quick and occasional heating of any part of one of the offices.

In the outlying towns where the Edison service is now supplied, the high chimneys on the small plants have been cleaned, painted white, and on them placed the words "Edison Light." The chimneys are brilliantly illuminated at night, making very effective advertisements.

A Producer-Gas Power Plant

An Inquiry into the Operation, Efficiency, and Construction of a Typical Modern Industrial Plant

By J. R. BIBBINS

A Paper Read at the Recent Meeting of the American Society of Mechanical Engineers

FIG. I—INTERIOR OF THE GAS POWER STATION OF THE GOULD STORAGE BATTERY COMPANY AND THE GOULD COUPLER COMPANY, AT DEPEW, N. Y. DIRECT CURRENT AT 250 VOLTS IS GENERATED FOR DISTRIBUTION THROUGHOUT THE WORKS BY THREE 150-KW. GAS-ENGINE UNITS

WITH all the present activity in power development for various purposes, industrial or otherwise, the value of the simple producer plant used exclusively for power generation seems to have been somewhat overlooked or at least questioned. Gas producers, especially for bituminous fuels, are quite familiar in metallurgical work, notably in the various iron and steel industries; and although the problem of gas purification presented in power work is somewhat more serious, yet experience has indicated several fairly simple methods of solution. The ability of the modern gas engine to take the place of the steam engine in general power work has likewise been questioned, as well as the capacity of gas engine and producer to work together harmoniously under widely varying load demands.

Fortunately neither of these charges is founded on a basis of actual conclusive experience, and it is the purpose of this paper to present some practical data upon the operation of a thoroughly representative commercial gas power plant, one in which a high measure of success has been obtained through intelligent engineering and supervision. Even though some minor improvements might still be suggested, the fact remains that this gas power plant is operating week in and week out, 24 hours per day, 6½ days per week, on a fluctuating manufacturing load, with a fuel consumption fully one-half that of a modern steam plant of like character and suited to the same work.

On an average of half load this 450-KW. plant ordinarily consumes from 2 to 2¼ pounds of coal per kilowatt-hour, and, on heavier loads, has reached as low a consumption as 1½ pounds per kilowatt-hour in regular daily running. During heavy loads the plant has repeatedly developed 530 KW. without the battery on maximum fluctuations, which represents an overload of 18 per cent. rating. Furthermore, with the exception of the engineers in charge during the two watches, the plant is operated by attendants originally quite unskilled in gas work; up to the present writing, however, no complete interruption of service, traceable to defective equipment, has been recorded.

These facts are thought to be sufficiently impressive to warrant their presentation, particularly as this plant may be regarded as exemplifying modern engineering practice and the service resulting therefrom. It is hoped that the considerable descriptive detail appended will be excusable as more or less essential to a full appreciation of the subject. The choice of a single example seemed to provide a better opportunity for detailed treatment.

CHARACTER OF SERVICE

The plant in question serves the entire Gould manufacturing properties at Depew, a suburb of Buffalo, N. Y. Two complete works are located here, one devoted to the manufacture of storage batteries and the other to the manufacture of railroad specialties, principally automatic couplers. The latter contains a large and well-equipped steel foundry. Both are electrically driven and lighted throughout from the central gas power plant.

Contributing to the station load are a large number of labor-saving machines of different types, such as electric traveling cranes, charging tables, transfer locomotives, elevators, conveyors, fans, pumps and machine-shop tools. The storage battery works also use considerable current at times for "forming" battery plates.

TABLE I.

EQUIPMENT DATA.

450 kw. Producer Gas Engine Power Plant.
Service—Power, some lighting.
Capacity of Plant—450 kw.
Number of Units—Three, 150 kw.
Distribution System—D. C. two-wire.
Pressure—250 volts, normal 230.
Power Building—45′x61′ inside.
 Height of roof trusses—28½′.
 Height of basement—9′.
 Total area per kw.—6.1 sq. ft.
 Net area of unit—15′x33½′.
 (With 6-ft. passageways.)
 Net area unit per kw.—2.87 sq. ft.
Walls—Red brick, exterior pilasters, limestone trimmings, steel frame work.
Roof—Wood, tar and gravel, steel trusses, monitor
Floors—Steel, wood, ¾″ maple finish.
 Basement floor—Concrete.
Foundation—Concrete.
Crane—Hand power.
Producer Building—Steel frame work
 Corrugated iron walls and roof.
 Charging floor—Boiler plate.
Cooling Pond—1,000,000 gals.
 Dimensions—280′ diam. by 93′ wide.
 Area (Power Plant) 7,300 sq. ft.
 Area (Producer Plant) 7,500 sq. ft.
 Total, 14,800 sq. ft.
 Depth—Normal 10′.
Holder—36″ diameter, single lift, 15,000 cu. ft.
Coal used—Bituminous run of mine.
Sources—Buffalo, Rochester & Pittsburg R. R.
Price—$2.30 per ton.
Heat value—13,500 B. t. u.
Engines—Westinghouse three-cylinder, vertical gas engines.
 Type—Single acting four-cycle.
 Capacity—235 B. H. P., 260 maximum.
 Normal Speed—200 r.p.m.
 Size Cylinders—(3) 19″x22″ stroke.
Ignition—110 volts and 8 volts.
 2 sets four cells storage battery.
 1 motor generator set, ½ kw.
Cooling Water (Jackets)—Motor driven centrifugal pumps.
 Two 2″ Worthington "Volute." 15 hp. motor, 1450 r.p.m.
Cooling Water (Scrubber)—2-stage motor driven. 2″ Worthington "Turbine" type. 15 hp. motor.
Compressed Air—100 lbs. from works, also 6″ 6″ Rand duplex single stage compressor. 10 hp. motor.
Generators—Westinghouse compound wound. Direct current.
Capacity—150 kw., 250 volts.
Switchboard—250 volt D. C.

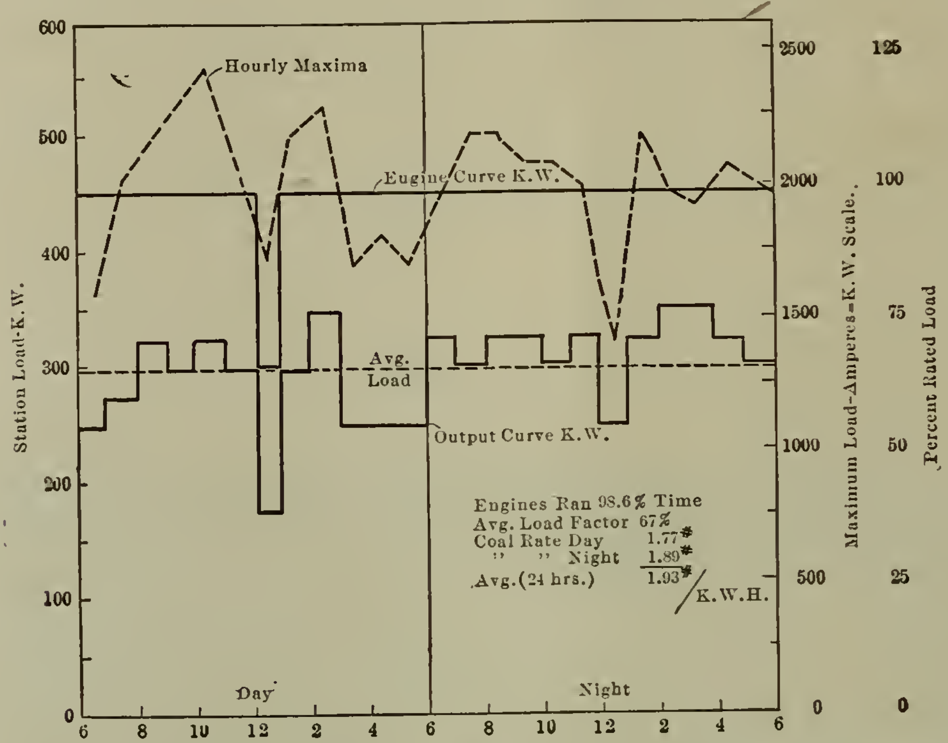

FIG. 2.—LOAD DIAGRAM FOR APRIL 13, 1905

Producers—Loomis-Pettibone.
 Type—Bituminous, duplex intermittent blast. 3′-8′ diameter.
Boiler—5′ diameter vertical tubular, utilizing waste heat.
Wet Scrubber—6′ diameter, vertical, coke, water sprays.
Dry Scrubbers—Two 9½′ diameter, in parallel; excelsior, 2 layers.
Valves—gear lift, water cooled.
Exhauster Roots—Simple engine drive.
Gas Main—12″ diameter.
Gas Risers to Engine—8″.
Fittings—Screwed.
Valves—Chapman gate.
Coal Handling—Bucket elevator, motor driven.

cent.) the general averages. As no system of notification is in force, the power station cannot be apprised of anticipated demands from the several production departments of the works. The storage battery forming load is, of course, steady while it exists, but it is liable to be abruptly thrown on or off at any time.

Several typical runs are shown in the accompanying logs, Figs. 2, 3, 4 and 5, for April 13, July 11-13, and Sept. 25, 1905, respectively. Although the recorded output is fairly steady through the day, the fluctuations correspond in some cases to overloads of 15-20 per cent on the engines.

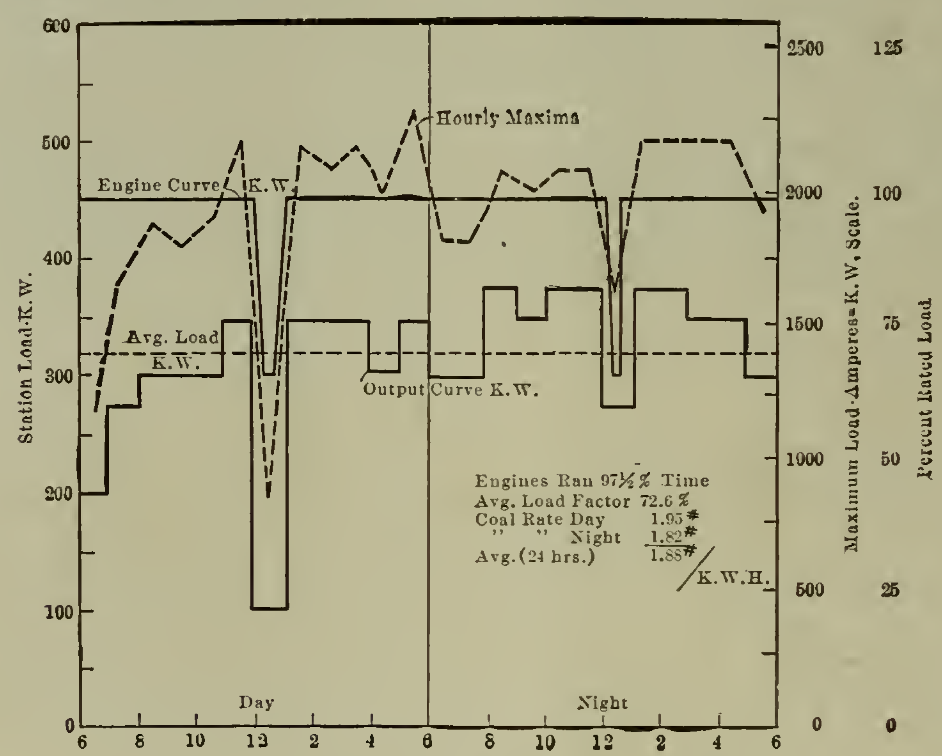

FIG. 3.—LOAD DIAGRAM FOR JULY 11, 1905

Although the power-station load is smoothed out to some extent by the overlapping of demands from these various sources, yet the larger machines pull heavily upon the system with the result that the load at the station bus-bar is subject to violent fluctuations, easily 80 per cent. above or below (on light loads 100 per

The original plant was entirely capable of handling these fluctuations, but on account of doubling the steel-plant load and adding electrically-driven air compressors, an auxiliary storage battery[1] was recently installed for the dual purpose of securing a more constant load on the engines with higher economy of fuel, and of increasing the average load. Formerly it was necessary to keep the spare unit constantly in service to tide over the peaks.

load hourly maxima and five equivalent to 8 per cent. overload. The average coal consumption for all purposes was 1.98 pounds per kilowatt-hour generated.

During a ten-day run in September, 1905, the results shown in Table III. were recorded. The engines averaged 87¼ per cent. of the possible running time and on 54 per

TABLE II.

TYPICAL LOG.

Gould Coupler Company, Depew, N. Y.

Gas Power House Daily Statement for September 26, 1905.

Time.	Producers in 1	2	3	Engines in 1	2	3	Pumps in 1	2	3	Station Wattmeters Output Kw.	Volts.	Maximum Amperes.	Remarks.
A.M. 7	△	△		△	△	△	△	△	△	1,459,800	230	1000	
8										,300	230	2100	8% overload.
9										,300	230	2100	
10										,200	230	2000	
11										,300	230	2100	
12				▽	▽					,300	230	2100	
P.M. 1				△	△					,100	230	2000	
2										,300	230	2100	
3										,200	230	2000	
4										,300	230	2000	
5										,300	230	2000	Full load about 1950 amperes.
6										,200	230	1800	
7										,250	230	1700	
8										,300	230	1900	
9										,300	230	1900	
10										,300	230	1800	
11										,300	230	1900	
12					▽					,300	230	1900	
A.M. 1					△					,150	230	1100	
2										,300	230	1900	
3										,350	230	1800	
4										,300	230	1800	
5										,300	230	1900	
6	▽	▽		▽	▽	▽	▽	▽	▽	,250	230	1700	

METER READINGS.

6.00 p.m.	1,462,600	6.00 a.m.	1,466,000
Previous	1,459,700	Previous	1,462,600
Output	2,900	Output	3,400
Coal, 6,000; Coke, ——		Coal, 6,300; Coke, ——	
Rate 2.06 lbs. per K. W. H.		Rate, 1.85 lbs. per K. W. H	

TABLE III.

OPERATING DATA.

450 K. W. Producer Gas Power Plant.

DATE. September, 1905.	Engine Hours Run.	% Full Day Run.	Output K. W. H.	LOAD—K. W. Average.	Rated.	Station Loading Factor.*	Fuel Used.	Coal Per K. W. H.	Coal Per B.H.P.Hr
20	71	98⅔	4850	202	450	45	11,100	2.29	—
21	65½	91	5275	220	450	49	11,400	2.16	—
22	70	97¼	6550	273	450	61	12,700	1.93	—
23	45¾	63⅓	4025	188	450	41.7	8,800	2.18	—
24, Sunday	24	-33⅓	2250	187.5	450	41.6	†6,600	†2.93	—
25	70½	98	6400	267	450	59	12,000	1.87	—
26	69¾	97	6300	263	450	58	12,300	1.95	—
27	70½	98	6700	279	450	62	12,600	1.88	—
28	72	100	6700	279	450	62	12,900	1.92	—
29	70½	98	6600	275	450	61	12,900	1.95	—
Average	63	87¼	5565	243.4	450	54	11,330	2.04	1.44

Westinghouse Vertical 3-Cylinder Engines—Loomis-Pettibone Producers.
*Loading Factor=% continuous generating capacity.
†Includes extra coke used on Sunday for starting new fires

PLANT DUTY

From the daily records of the plant an excellent idea of its operative efficiency may be obtained. These records, although not elaborate, are carefully kept and show not only the output and duty of the plant, but also the maximum loads that occur during the hour. A digest of a typical day's run is given in Table II. and shows continuous operation except at noon and midnight; to be exact, 97 per cent. of the elapsed time. The load averaged 263 KW., or 58 per cent of the generating capacity in service with nine full

[1] This battery, however, was not placed immediately in service, and does not affect the results presented in this paper, except in the matter of capital costs.

cent. station load factor[1] the plant consumed 2.04 pounds fuel per kilowatt-hour, or 1.44 pounds per B. H. P.-hour. With coal of 13,500 B. T. U. calorific value, the efficiency of this plant averages about 13.1 per cent., thus rivaling, if not excelling, the largest modern steam-power stations. On Sept. 27, the fuel rate was 1.88 pounds per kilowatt-hour (or about 1¼ pounds per B. H. P.-hour) with 62 per cent. load factor, corresponding to a plant efficiency of over 15 per cent.

The author has been deeply interested in the effect of the load factor of a plant upon its efficiency and commercial duty. An unusually good opportunity arose in analyzing the results of this plant and the approximate relation is presented in Fig. 6. In order to obtain a closer average, the "shotgun" method (Fig. 7) was used, plotting total fuel per day to output. Barring some unusual results occurring in the early days of the plant, the average fuel consumption is approximately a straight line within observed limits. From this the average fuel per kilowatt-hour may be obtained, Fig. 8, and the relation approximates a rectangular hyperbola within normal ranges of load. The upper convex curve, Fig. 8, expresses the kinetic or absolute efficiency[1] of the station, and it is interesting to observe that this small plant normally operates with an efficiency[2] between 12 and 13 per cent. average.

From the above data and the measured efficiency of the gas engine, the efficiency of the producer plant may be roughly estimated. Assuming 50 per cent. load factor, the average plant efficiency is 12 per cent.; as the efficiency of the engines is approximately 17 per cent. at this load (see Fig. 11), the producer plant operates at an efficiency of slightly above 70 per cent. With a higher load factor of 75 per cent., the plant efficiency is 13 per cent. on an average, that of the engines 20 per cent. and of the producers 65 per cent. During an especially good day's run, as on Sept. 27, the efficiencies were as follows:—Plant 15 per cent., engines 21 per cent., producers 71.5 per cent. These results indicate that the producer plant is, from an everyday operative standpoint, fully as efficient as a high-grade boiler plant and frequently more so. It is certainly not more difficult to handle.

As to the cost of power the following analysis reveals a total cost of well under 1 cent per kilowatt-hour, including fixed as well as operating charges. At normal prices, coal[3] costs $2.30 per ton. Assuming an average daily output of 5000 to 10,000 kilowatt-hours representing the probable minimum and maximum for full working days, and adding the

[1] $\text{Load factor} = \dfrac{\text{Avg. 24-hr. station load}}{\text{Rated capacity}}$

$\text{True load factor} = \dfrac{\text{Avg. 24-hr. load}}{\text{Maximum}}$

[1] $\text{Kinetic efficiency is defined as} = \dfrac{\text{Thermal equivalent of work done}}{\text{Heat in coal}}$

[2] Since the above observations were made the plant has been giving much better efficiency, the coal consumption averaging 1.8 per kilowatt-hour with an 85 per cent. load factor. This corresponds to a plant efficiency of over 15.4 at the engine shaft, or 14 per cent. at the switchboard. Several runs averaging 1.55 pounds per kilowatt are recorded, equivalent to a plant efficiency of 17.7 per cent. at the shaft, of 16.3 per cent. at the switchboard.

[3] Buffalo, Rochester and Pittsburg bituminous run of mine, 13,500 B. T. U. per pound.

fixed or capital charges amounting to about 9 per cent. on $91,650 (or $81,000 excluding the battery), the distribution of cost items is substan-

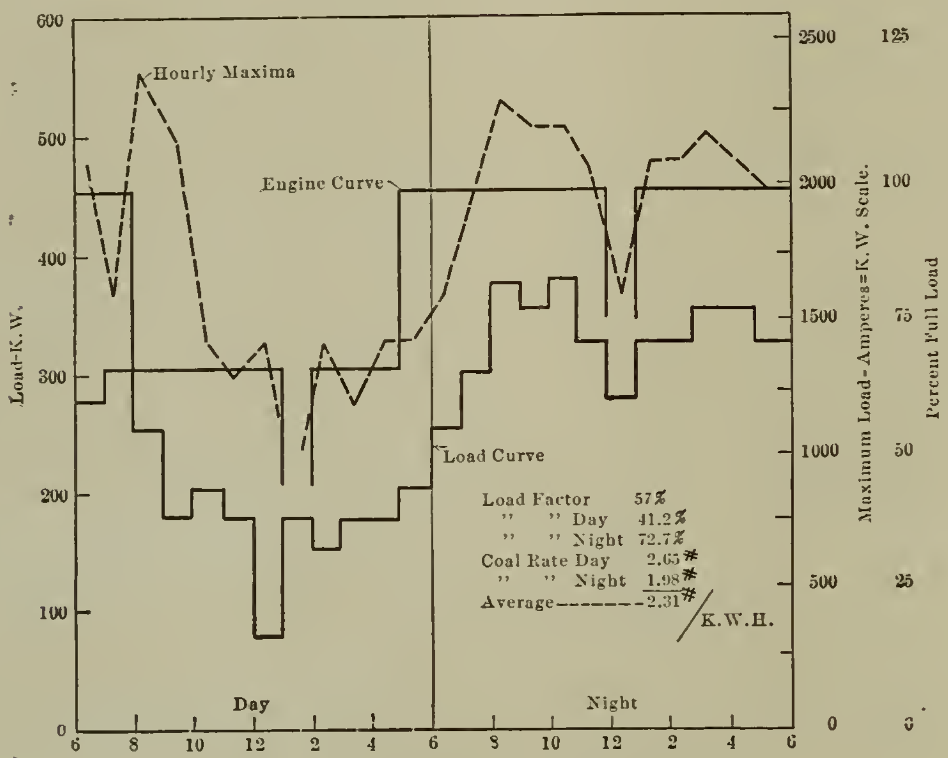

FIG. 4.—LOAD DIAGRAM OF JULY 13, 1905

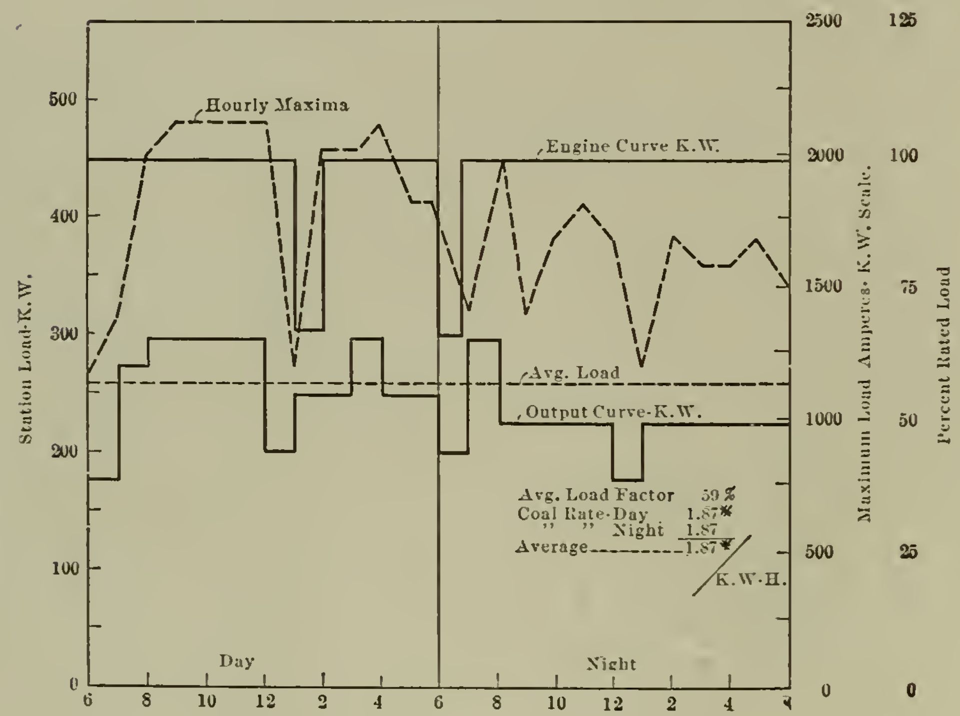

FIG. 5.—LOAD DIAGRAM OF SEPT. 25, 1905

APPROXIMATE POWER COSTS.

	Minimum.	Normal.	Maximum.
Output—K. W. H. per day	5,000	8,000	1,0000
Fuel—Cents per K. W. H	0.25	0.22	0.20
Labour—Cents per K. W. H	0.28	0.17	0.14
[1]Supplies and repairs (estimated) c. K. W. H	0.17	0.13	0.11
Operating costs, c. K. W. H	0.70	0.52	0.45
Fixed charges	0.45	0.28	0.22
Total costs, c. K. W. H	1.15	0.80	0.67

tially that given in the table above.

In order to emphasize the effect of load factor, Fig. 10 has been prepared showing the relation of both capital and operating costs to the station load factor, the former plotted above and the latter below, the X axis. Total cost of power is given by the total ordinate. Observe the rapid change in costs on light loading, especially of fixed charges. Coal, on the other hand, remains fairly constant; labour, a constant charge, increases rapidly on light loads, and supplies and repairs, a variable charge, less rapidly. The importance of load factor is well brought out by this diagram, that is, the total cost of power is halved by increasing the load factor from 24 to 55 per cent. An industrial or railway power plant usually operates on about the latter figure, a moderate sized lighting plant on the former; hence, the danger of indiscriminate comparisons of operating costs in power-plant work.

Considering that the results above enumerated have been obtained from a comparatively small plant, operating under conditions by no means conducive to the attainment of the highest economies, the Depew plant offers a striking object lesson that should not fail of appreciation among engineers confronted with similar problems; and much credit is due the Gould Company through its consulting engineer, W. E. Winship, and its resident manager, J. O. Gould, for early appreciation of the advantages of gas power and efficient management of the Depew property. The author begs to acknowledge their courtesy and assistance in placing cost and operating data at his disposal.

GROUNDS AND BUILDINGS

An excellent location has been chosen for the power plant adjacent to the main line of the Lackawanna Railroad. In the intervening space is a large semi-circular reservoir, serving the two-fold purpose of a cooling pond and reservoir for general fire-protection, and incidentally enhancing the attractiveness of the property to no small degree.

For convenience to coal supply the producer house is located several hundred feet in the rear, adjacent to a large metallurgical producer plant serving the steel furnaces. A single coal-handling system thus serves both producer equipments. This arrangement of buildings emphasizes the possibilities in gas power work of separating, at any distance, the producer and gas-engine parts of a power plant for operative, or other, convenience.

Brick, steel and concrete are largely used as building material. In the producer house where the fire hazard is, of course, considerable, no wood at all is employed, walls and roof being constructed of corrugated iron and the charging floor of boiler plate. Spacious monitors in both buildings provide the very necessary ventilation and light.

GENERATING PLANT

Considerations of operating economy largely influenced the choice of gas engines for this plant where

[1]These charges are estimated, owing to absence of more accurate data and the comparatively short time plant has been in operation. Assume 25 per cent. of total power costs at 50 per cent. load factor, hence the estimate is conservative.

It should be noted that were the plant to operate regularly at the lower load factors less labour and supplies would be required and the light load costs would be correspondingly reduced. The curves, Fig. 10, are based on full plant in service operating continuously.

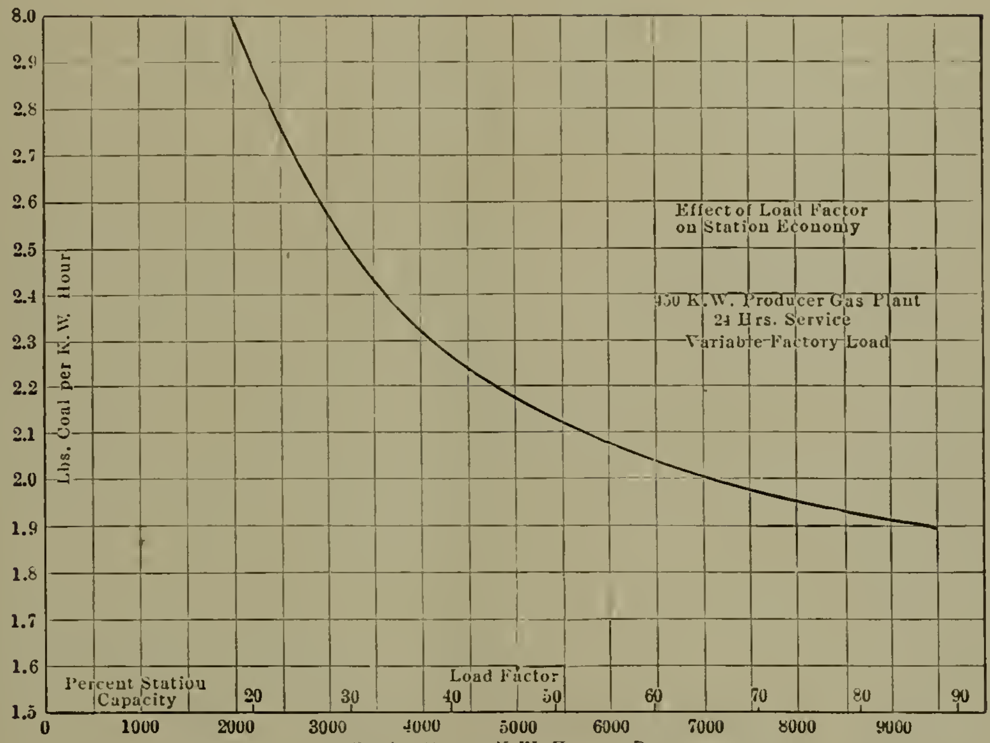

FIG. 6.—RELATION OF FUEL RATE TO STATION LOAD FACTOR, PLOTTED FROM OBSERVED DATA

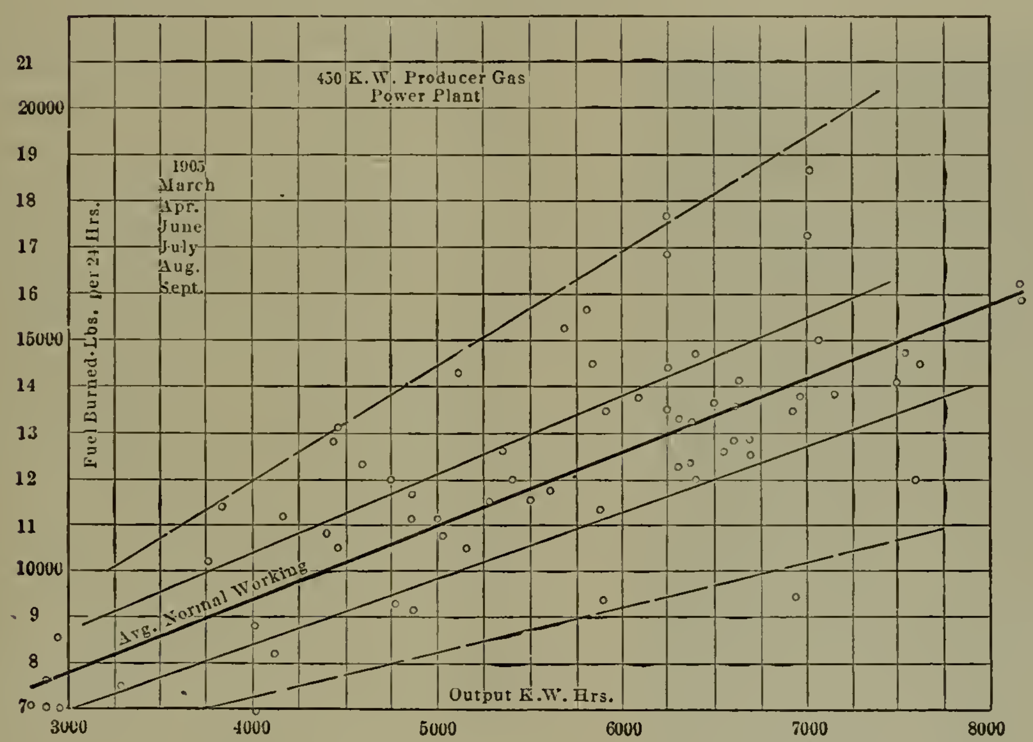

FIG. 7.—FUEL CONSUMPTION AT VARIOUS OUTPUTS. GEOGRAPHICAL METHOD OF OBTAINING TRUE AVERAGE

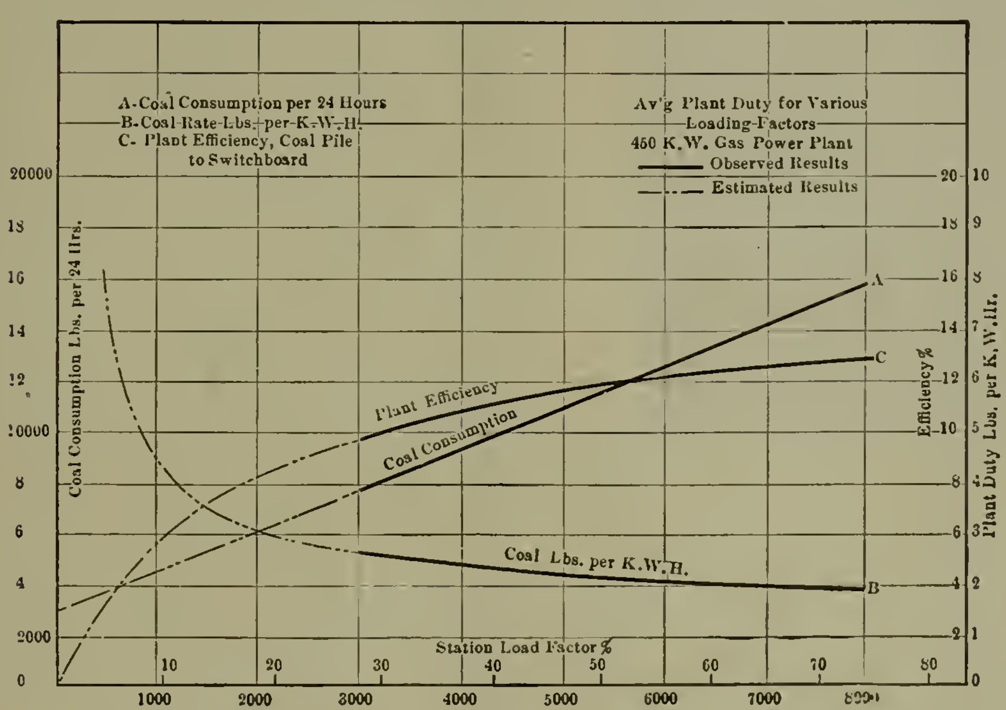

FIG 8.—AVERAGE PLANT DUTY AT VARIOUS LOAD FACTORS

steam coal costs from $2.25 to $2.40 per ton, and gas coal about the same. At this price it was estimated that, although the difference between the steam and gas was small on half-day working, for a 24-hour day the latter's advantage was decisive.

The installation of three units of similar size and identical construction wisely avoided the duplication of parts which two or three sizes of engines would have occasioned. By the use of direct-connected units a very compact power-house arrangement has resulted, the total floor area per kilowatt being 6.1 square feet, and the net area of each unit with 6-foot passageways 2.9 square feet per kilowatt.

The efficiency of these engines as heat engines is well indicated by the appended results of tests[1] shown in the accompanying Table IV. and in Fig. 11 also. In the latter the upper concave curve represents the gas consumption per B. H. P. under different loads and the convex curve, the kinetic or absolute efficiency.

The ability to convert into useful power over 25 per cent. of the effective heat in the gas gives evidence of high efficiency.

These engines operate on the four-stroke cycle involving constant quality of mixture and throttling governing. The actual proportioning of gas and air is accomplished by two plug valves at the bottom and the top of the mixing chamber, respectively, each with graduated index. These valves may be set by hand at any time to accommodate varying qualities of gas. An automatic diaphragm pressure regulator reduces the pressure of the incoming gas to atmosphere at the engine.

ENGINE AUXILIARIES

A most important factor in the successful operation of the engines is the ignition apparatus. For increased security each igniter plug has two sets of points, each set independently connected. Should one set of points, through any cause, become unfit for use, a small double-throw switch may be reversed, thus turning the ignition current through the other points. In addition, three independent sources of current have been provided, all the apparatus being contained in a central ignition cabinet. For starting, one of two 8-volt storage batteries

[1]These were made at the builder's works on natural gas, which was at that time the only fuel available for testing purposes. As engines for producer gas are usually constructed for somewhat higher compression than those operating on illuminating or natural gas, their efficiency would presumably be slightly better on natural than on producer gas fuel; yet for commercial work a difference of 15 pounds in compression would scarcely be appreciable.

is used. For running, a small ½-KW. motor-generator unit is used delivering 110-volt current to the igniters through incandescent lamps, which furnish a valuable "tell-tale" for

TABLE IV.

ENGINE EFFICIENCY.

Average of Tests—Three 19"x22" Single Acting Four-Cycle Gas Engines—Engines Nos. 741, 742, 743.

LOAD.	Over.	Full.	Half.	Remarks.
Brake horse power	325.3	239	121.3	By Prony brake.
Speed r.p.m.	198	203	206.3	By counter.
Gas per hour	3,547	2,840	1,985	Corrected to 62° F. 30" Hg.
Gas per B. H. P. hour	10.9	11.87	16.36	Corrected gas—no load—1,250 ft. per hr
Heat value gas*	920	920	920	Effective B. T. U. per cu. ft.
B. T. U. per B. H. P. hour	10,030	10,910	15,050	
Brake kinetic efficiency	25.37	23.32	16.9	B. H. P. basis.
Mechanical efficiency	89	87.5	82.5	Estimated.
Indicated kinetic efficiency	28.5	26.7	20.5	I. H. P. basis.
Speed variation-max	4.2%	...	...	No load speed 206.6.
Speed variation—No-full load	...	1.8%	...	Average speed.
Speed variation—No-half load	...	...	0.7%	
Per cent full rating	138.4%	101.6%	51.6%	On producer gas.

*Pittsburg Natural Gas—Junker Calorimeter.
Engines rated 235 B. H. P. on 130 B. T. U. Producer Gas.

"open circuits," "grounded igniters," or "hanging fire" of igniters. These two sets of storage batteries are charged alternately through a bank

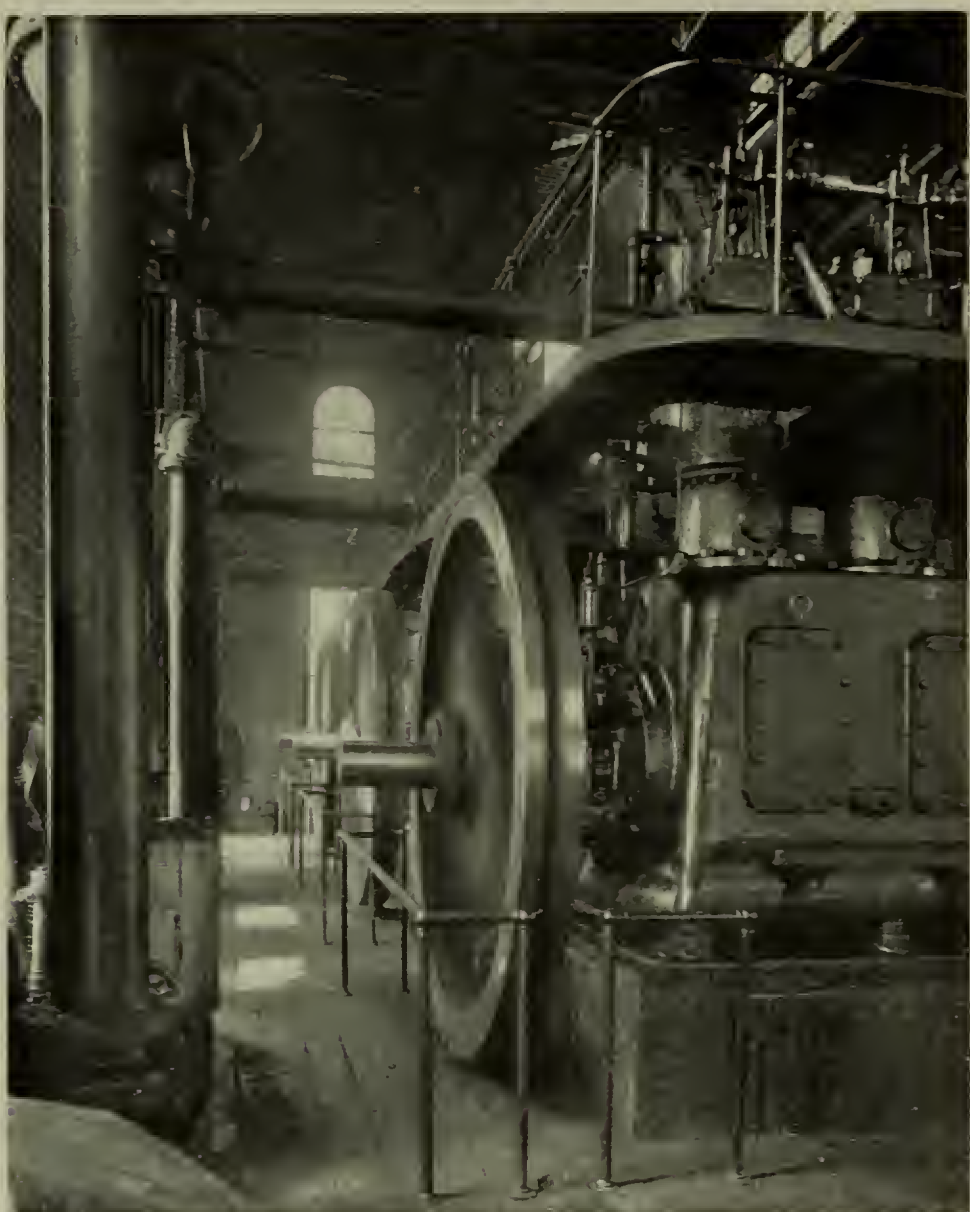

FIG 9.—ENGINE ROOM SHOWING GAS PIPING AND POSITION OF GAS REGULATORS

of lamps from the motor-generator or from the main station bus-bar, one or the other set being always available in an emergency. By means of small double-pole switches at the igniter cabinets, throwing over from the low to the high-tension system may be instantly accomplished without in the least disturbing the engines. The ignition problem has thus been handled with great care in the provision of six individual combinations of current supply.

Starting of the engines is accomplished as usual by compressed air drawn from a pipe connection to a compressed air line in the works or from the relay compressor. Although only 90 to 100 pounds pressure is ordinarily carried, yet the engines may readily be brought up, cold, to full running speed, within 30 to 40 seconds. With higher air pressure available, starting may be accomplished in even less time, as the mixture ignites more readily when quickly compressed, owing to the smaller opportunity for the dissipation of internal heat.

Another important part of the plant equipment is the circulating water system for cooling jackets, combustion chambers and exhaust valves. Motor-driven rotary pumps are ideally suited to this work on account of the moderate pressure required—about 25 pounds per square inch. Two of these pumps (one for relay) serve the engine plant while a third, of the two-stage turbine type, serves the gas producer scrubber in which a higher pressure is desirable. Although each pump is driven by a 15-H. P. motor, the power ordinarily required is considerably less than this, especially in moderate and cold weather when the quantity of water supplied to the engines may be largely reduced by throttling the pump outlets.

COOLING RESERVOIR

Previous mention has been made of a cooling pond. This has a normal depth of 10 feet with a total capacity of about 1,000,000 gallons. It is approximately semi-circular in plan and is divided radially into two compartments to separate the comparatively dirty scrubber water from the pure jacket water. All make-up water used at the plant is delivered to the pure-water pond through the engine jackets. The excess overflows into the scrubber-water pond and thence to the sewer. It is of interest that nearly all of this "make-up" water is supplied from roof drainage. City water is comparatively expensive (10-15 cents per 1000 gallons) and this utilization of roofage insures an important economy. The pond also supplies feed-water for some steam boilers. Cooling water for the engine is drawn from near the bottom through a screen house, while the hot jacket water is returned to the surface of the pond, about 150 feet distant.

During the progress of the water from inlet to outlet enough heat is dissipated to the earth and atmosphere to reduce the outlet water to the proper temperature. During periods of extreme heat and humidity when the cooling process is retarded, a larger quantity of water may be sent through the jackets to compensate for the lesser difference in temperature. For this the rotary pumps are well suited. In September, 1905, the following observations were made:—

Jacket water entering pond	99.3° Fahr.
Surface of water near inlet	78.8° Fahr.
Air	73.8° Fahr.
Bottom of reservoir near outlet	76.1° Fahr.
Surface of reservoir near outlet	77.9° Fahr.
Average load on plant	310 kw.=500 hp.

Thus on a fair day with practically seven-tenths load on the plant there was a difference in temperature of 1.8 degrees Fahr. in 8 feet depth of water, 0.9 degree Fahr. difference between the temperature of reservoir at intake and outlet, 4.6 degrees Fahr. difference between air and mean reservoir temperature, and 23.2 degrees Fahr. total cooling, as there was no overflow from the power pond at the time this cooling was effected from about 7300 square feet of exposed water surface. Apparently considerable cooling took place through the transmission of heat through the bottom of the reservoir.

PIPING

Some trouble has been experienced with the gas gates, due apparently to cumulative deposits of carbon, and frequently it becomes impossible to seat the valves tight. In work of this class it would seem that a parallel seated, quick-closing gate would be best suited, being self-cleaning, and the gas could be cut off almost instantly in case of emergency.

The engine exhausts all discharge into a cast-iron header running beneath the floor to a concrete exhaust well outside, serving as a muffler. Unfortunately, it is impossible to cool these exhausts by water sprays on account of the large amount of SO_2 in the gas. If water were used, as is the practice with natural gas, the piping would soon be destroyed by corrosion. As some 30 per cent. of the total heat value of the gas is lost in the exhaust, radiation is a somewhat disagreeable feature, especially in warm weather. This trouble may, however, be obviated by enclosing the piping in a concentric sheet metal casing, through which rapid circulation may be maintained from basement to ventilators in the roof. It is also possible that a reinforced concrete duct might be employed for exhaust piping, moulded in sections, cemented in position and encased in sheet steel. If rigidly supported, this material should easily withstand both the heat and corrosive action of the exhaust vapours when water cooled in the usual manner.

The muffler well is, to be sure, a common arrangement in gas power plants, but most certainly could be improved upon. First, the noxious products of combustion rising from the pit, although located in the open, are driven directly into the engine room during certain prevailing winds, to the great discomfort of the operators. Second, if the exhaust pit is carried to any considerable distance from the power house, a serious back pressure is imposed on the engines, owing to the friction of the high pressure exhausts on the internal surface of the main.

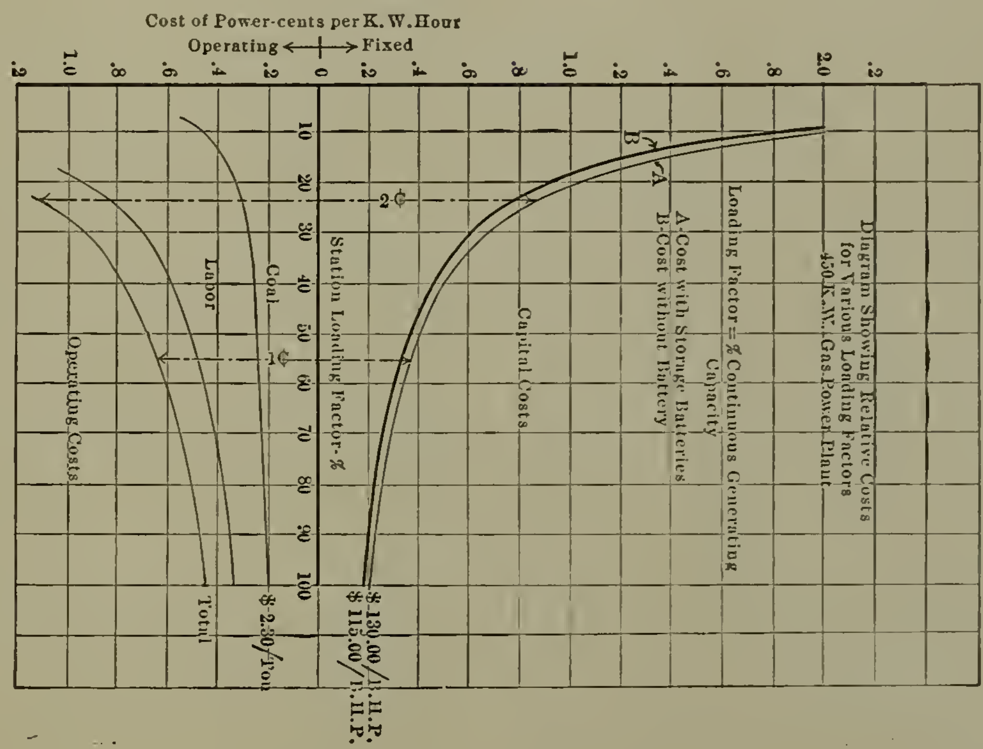

FIG. 10.—RELATIVE POWER COSTS AT VARIOUS LOAD FACTORS

Usually the well is located close to the building with a short standpipe. This outlet is almost invariably too small, resulting again in serious back pressure from throttling. And it usually occurs that, sooner or later, the structure is dismantled by sudden pressures due to delayed combustion or other causes. A more logical arrangement would seem to be as follows:—(1) A brick or concrete exhaust well of large dimensions built next to the power house foundation wall and loosely filled with large broken rock; (2) a brick stack extending to the roof and built into the building structure integral with pilasters, thus taking advantage of the reinforcement offered by the steel skeleton of the building; (3) simple sheet steel flap doors or louvres inserted in the roof of the exhaust pit and at two or three points in the chimney to relieve occasional local pressures. In this manner the noxious gases are easily taken care of by a flue of cheap construction, agreeable appearance, and ample capacity for any contingency.

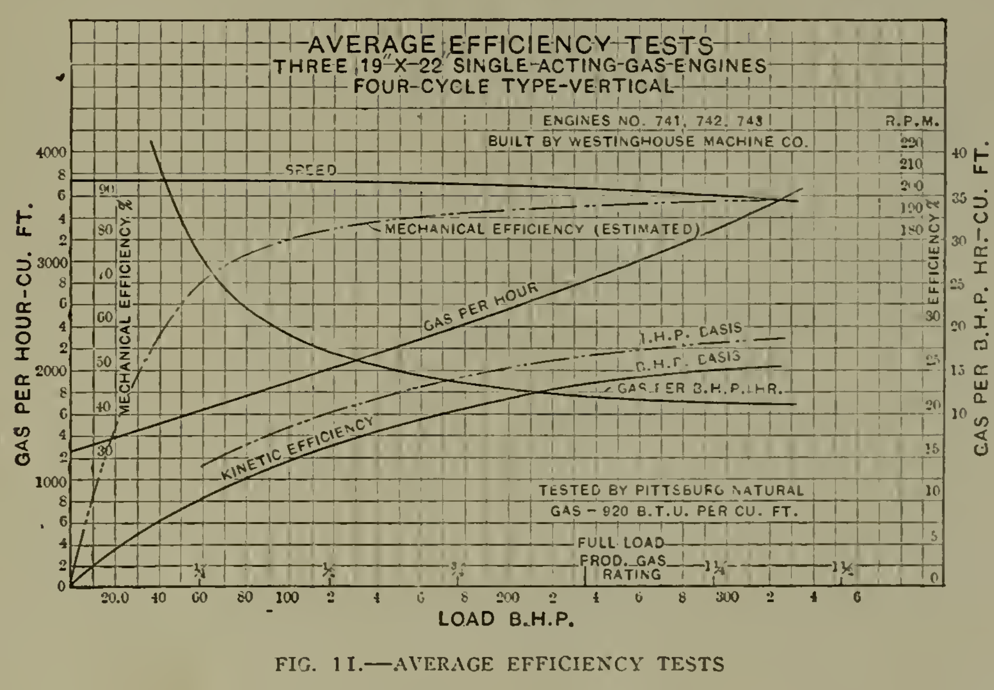

FIG. 11.—AVERAGE EFFICIENCY TESTS

The water cooling piping is simple, a manifold supplying all three cylinder jackets in parallel. Water enters at the bottom of the jacket, emerging from the top. A small pipe loop at the discharge end of the upper manifold, with vent cock at the top to break the vacuum, serves to prevent the syphoning effect which, under certain conditions, might pull all the water out of the jackets, leaving nothing but steam. This vent is useful as a tell-tale, showing stoppage of water supply.

In cooling the exhaust valves a fairly constant supply is desirable,

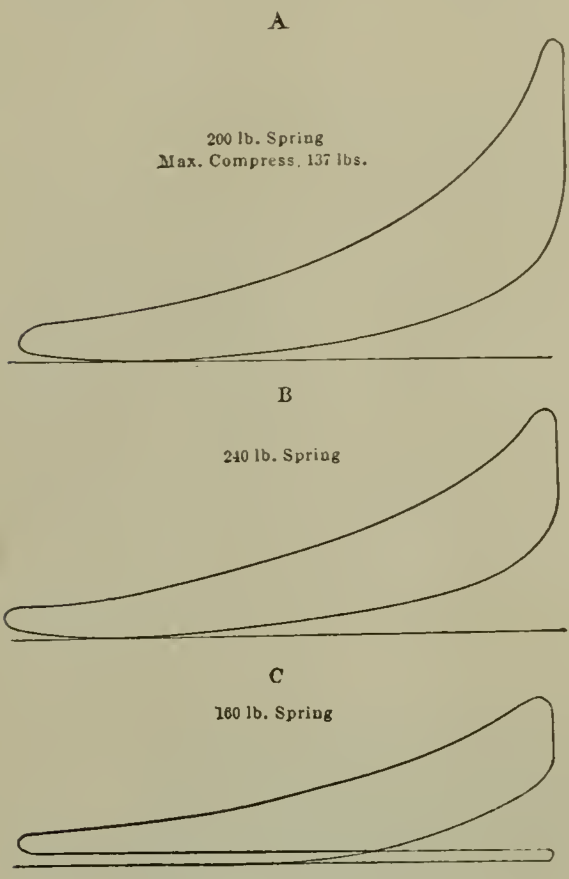

FIG. 12.

irrespective of the load. The arrangement shown in the sketch, Fig. 13, is, therefore, employed, by which the jacket water may be throttled as much as desirable, while constant

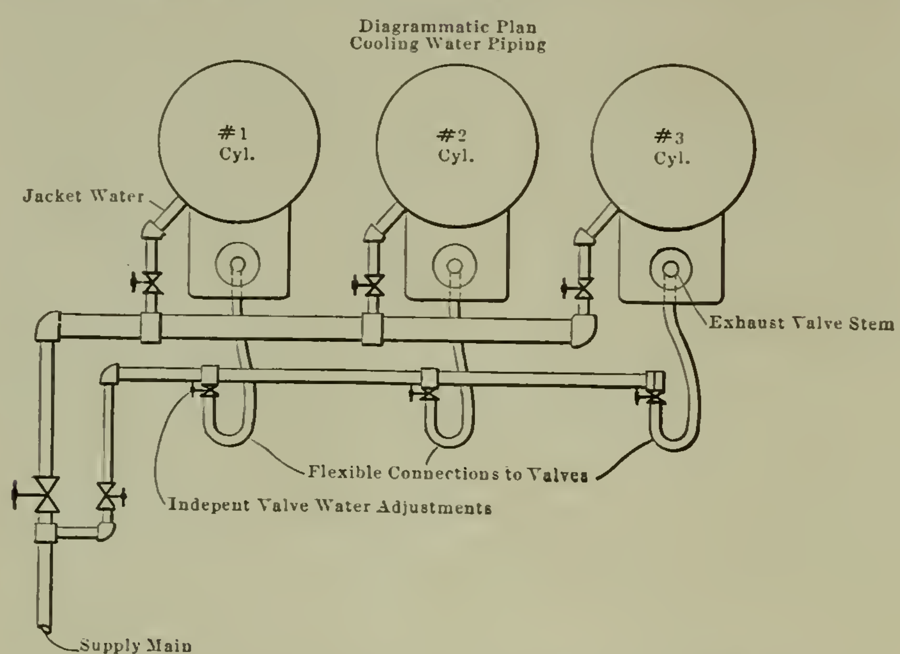

FIG. 13.—PLAN OF COOLING WATER PIPING FOR CYLINDERS AND EXHAUST VALVES

head is maintained at the exhaust valves.

OPERATION OF ENGINES

Four men, two to a shift, operate the generating plant, the oilers and the two engineers being formerly steam engine operators. The personal attitude of the chief engineer toward the gas engine plant well refutes the frequent argument that gas engines require more skilled operators than steam engines; the plant not only requires less actual manual labour to keep in running order, but it is fully as responsive to good handling as a steam plant. All things considered, he "would regret to go back to steam." The fact that the engines are often left in charge of, and operated by, the oilers, illustrates the point in view.

While the producer is undergoing renovation on Sundays, the engines are also inspected in rotation, mixing valves flushed down with gasoline to remove lampblack deposits (likewise cylinders, now and then, to keep the packing rings free), valves are ground in and igniters replaced when necessary, jacket deposits cleaned out when obstructed to any extent, and the engines generally adjusted. Reducing valves are also cleaned at intervals, from carbon deposits.

Practically the only trouble experienced thus far has been the occasional cutting of an exhaust valve, presumably due to cumulative carbon deposits on the valve seats. The lampblack has also occasioned some difficulty in lubricating valve stems. Igniters, of course, wear down gradually, but extras are always kept on hand and repointed as fast as necessary. Usually one igniter will last from six to nine months without repointing.

Since commencing normal operation engine repairs have been confined to these two items and are comparatively light, considering the conditions of operation. Very little trouble has been experienced with lubrication, as the main working parts are automatically supplied by the splashing of oil. All oil used in outer bearings returns to the crank case to make up that lost through evaporation. When the oil reaches too high a level the excess is drawn off, filtered and used over in the bearings.

In starting and stopping the engines the attendants have acquired so much skill that the barring lever is seldom used. By manipulating the air valves just as the engine comes to rest it is not difficult to bring the air cams in starting position, so that no time need be lost in barring the engine around to the position for starting.

PRODUCER PLANT

A notable feature of the producer plant is that it is capable of gasifying bituminous coals without making quantities of tar. The process is intermittent, embodying the now more or less well-known system of passing the green hydrocarbon distillates through a secondary fire bed which has previously been brought up to the proper temperature by blasting with air.

Since the plant was started, a fair grade of soft coal (B. R. & P. run of mine) has been used, averaging about 13,500 B. T. U. per pound. Although this coal presumably contains 35 per cent. of volatile, tar destruction in the producers is complete, but, at the same time, a considerable quantity of lampblack has resulted which has made it necessary to devise special means to handle this by-product. No attempt has been made to market it, as some is used in the preparation of paints for castings, etc.

Straight producer gas is not made directly, but water gas and air gas are made at alternate intervals of varying duration, according to richness of the gas desired. In metallurgical plants the two gaseous products of the system are often handled separately, the water gas being used for heating furnaces on account of its high flame temperature and the blast gas in gas engines for power purposes. And it is an interesting fact that, although this blast gas would be absolutely unfit for any other use on account of its comparatively low calorific value,—from 80 to 90 B. T. U. per cubic foot,—yet it is quite suitable for gas engine work, in that it is not at all snappy (as is water gas), and, therefore, permits of higher compression. At Depew the two gases are mixed in a single holder in the proportion generated.

In this system two producers constitute a unit. Usually it is desirable to have a separate unit on hand for relay purposes. Here this was especially necessary in order to provide an opportunity for freeing the producer from clinker formed during the week's run. At Depew a novel arrangement was first employed, in the form of a clover leaf, with three producers united at top and bottom by a T-pipe connection with the necessary water-cooled valves.

It was then possible to renew one producer fire per week in rotation, and, at the same time, save the cost of a fourth producer to complete the duplicate unit. Through no fault of this arrangement, however, it was not an entire success, owing to the difficulty in preventing the leakage of water gas into the idle producer through the valves. This difficulty has now been overcome, and a complete relay plant, including scrubbing equipment, is provided in the adjoining producer building with sensibly better results than before.

PRODUCER AUXILIARIES

A feature of the system is that all steam required is generated entirely from the sensible heat of the gases coming from the producers which would otherwise be wasted in cooling water. This condition, however, obtains only when the plant is heavily loaded. Running light, it would be difficult to make sufficient steam to operate the producer auxiliaries. An air auxiliary boiler would have to be drawn upon. With the high "heats" necessary in the intermittent process, this represents an important saving. The boiler, however, requires weekly cleaning.

The proper cleaning of the gas is a difficult problem, owing to the fact that lampblack does not easily adhere to a wetted surface, as does ordinary cinder dust. In this plant the gas first passes upward through a wet scrubber containing several tiers of small coke constantly wetted down by water sprays. A thin layer of dry excelsior is also used in the top tiers. Emerging from the wet scrubber, the gas enters two large, dry scrubbers filled with several tiers of excelsior and piped up in parallel so that not only the velocity of the gas is reduced, but also the amount of gas handled by each drier. Finally, an engine-driven Root's exhauster delivers the gas to the holder.

The various valve movements are handled mechanically by rack gears with operating wheels conveniently placed on the level of the operating floor.

PRODUCER OPERATION

The present method of operating the producer plant requires an air gas run of ten to fifteen minutes, according to the demand for gas at the power plant, and a water gas run from one-half to three-quarters of a minute, the resulting mixture being well suited to power work.

Frequent testing of the quality of the gas made is not now practiced on account of its uniformity under the present operating condition. The holder, of course, greatly assists in insuring uniform gas at the engines. At the same time, it provides sufficient capacity for operating one unit at full load for about three-quarters of an hour, the full plant in inversely proportionate time. Storage capacity is particularly valuable when a new fire is being put into service. This is usually done during the noon hour, when the load is light, so that a lowering of the heat value of the gas is relatively unimportant.

In ordinary operation it is a simple matter to observe the quality of gas by means of two sampling flames always in view of the operators. One consumes gas from the holder; the other consumes freshly made gases as they leave the dry scrubber. Any irregularities may then be readily detected. Calorimeter tests show the gas as made at the present time to average slightly above 100 B. T. U. per cubic foot (see Table V.). This comparatively low heat value is, of course, due to the preponderating period of blasting.

With the rate of water gas mixing practically fixed, the only variable factor to compensate for varying demands for gas is the rate of blasting; hence, there is a long and subdued air gas run, with a rapid but short run on water gas. During the second test, data of which are given in Table V., the gas consumption was observed to be about 1100 cubic feet per minute at a load of 395 KW. This is equivalent to 167 cubic feet per kilowatt-hour at seven-eighths load on the generating units, and represents approximately a duty of 16,700 B. T. U. per kilowatt-hour, or a little over 11,000 B. T. U. per B. H. P.-hour.

Coal consumption is determined by direct weighing in the producer house. Each shift weighs up enough coal at the start to run the plant through twelve hours; should there be a surplus at the end, it is weighed back and charged to the next shift, thus making each shift responsible for all fuel used during their run.

The entire producer plant is operated throughout the week by four men, two to a shift, with some additional labour on Sundays for cleaning. All the attendants were unskilled foreigners before taking up the producer work. During a half-day shut-down of the plant on Sundays, all renovating of the producer equipment is done; boiler tubes are cleaned, wet scrubber washed down, the excelsior in the dry scrubbers taken out and shaken free from lampblack, gas mains flushed out and a new fire started in the idle producer. At the same time, another producer is taken out of service, fires are drawn, and during the week, after it has had an opportunity to cool off, the hard clinker, which adheres to the lining, is broken off. For the starting layer of a new fire bed, coke is used to the extent of some 3000 pounds per producer, a sufficient quantity to affect the coal consumption of the succeeding day. If allowed to form to any extent, clinker constitutes a frequent source of trouble in operating the plant, and it is important that the selection of coal be made with this in view. With fires fairly free from clinker the suction required for blasting may be only 8 to 10 inches of water, but with fires badly clinkered it may run up to 25 inches. With 10 to 15 inches drop in the scrubbers, this imposes from 30 to 40 inches suction on the exhauster, thus largely increasing its steam consumption.

TABLE V.

CHARACTERISTICS OF POWER GAS.

Typical Analysis.

Date, June, 1905	20th	21st	23d
Number of hours test	3	10	10
Intervals of tests (minutes)	15	15	15
Minimum calorific value	98	91	91
Maximum calorific value	113	110	104
Average calorific value	105	100	100
Maximum variation from avg.	7½%	10%	9%

DATE.	H.	CO.	CH_4	O_2.	COi.	N.
Sept. 9, 1905	9.50	21.0	1.9	0.6	6.5	60.9
Sept. 12, 1905	10.13	22.8	2.2	0.4	5.6	58.9

The Substitution of the Electric Motor for the Steam Locomotive

In discussing the question of the electrification of steam railroads in a paper read at the January meeting of the American Institute of Electrical Engineers, L. B. Stillwell and H. St. C. Putnam divided their topic into four parts, as follows:—1. A record of certain facts relative to heavy electric traction which have been established by experience; 2, calculations of relative costs of steam and electric traction in railway service based upon these facts; 3, the transcendent importance of standardizing electric railway traction equipment as rapidly as may be consistent with progress; and 4, the question whether a frequency of 25 or 15 cycles per second should be adopted in railway operation by alternating-current motors.

Under the first head were discussed the passenger service factors contributing to increased earning power, such as frequency of service, speed, safety, increased capacity of the line, and the like. In connection with this the results obtained by the electrification of transportation systems in New York City were dealt with, with diagrams showing the increase by years.

In dealing with comparative costs of operation, the items in maintenance of way and structures, maintenance of equipment, conducting transportation, and general expenses for steam operation were given and compared with the estimated cost of electric operation, the grand total showing, with steam at 100 per cent., a cost of 82.08 per cent. by electric operation.

The standardization of electric railway traction equipment, the authors thought, should have serious consideration. It would seem feasible and eminently wise to agree upon standards of practice in respect to location of the third rail, the location of the overhead conductor used with single-phase, alternating-current system, and the frequency of alternating-current traction systems. It is equally desirable, but probably less easy, to agree upon a standard system of multiple-unit control for train operation.

Comparing the relative advantages of 25 cycles and 15 cycles in railway service, the salient advantages of the former were stated to be the following:—

1. It is to-day in extensive use in plants developing and distributing energy for lighting and power purposes, and through sub-stations equipped with converters for the operation of many interurban lines. It has been adopted on a very large scale by such companies as the Interborough Rapid Transit Company, of New York, for the operation of its subway, surface and elevated lines, by the Pennsylvania and Long Island Railway Companies for the electrification of New York terminal service and operation over a considerable part of Long Island, and by the New York Central for the electrification of its terminal service. It is also the frequency developed by all of the great power plants at Niagara Falls, and from this source of power it is possible for all railway lines within a radius of 150 miles, or an even greater distance, to procure an ample supply of very cheap power.

It has been adopted by the New York, New Haven & Hartford Railway Company, the pioneer among American railroads in the adoption of the alternating-current motor in heavy railway traction, and by the Grand Trunk Railway for the electrification of the Sarnia Tunnel. Alternating current at 25 cycles is also utilized without the interposition of converters by the motor equipment on a dozen or more interurban trolley lines.

2. Our great manufacturing companies have drawings, patterns and dies which enable them to manufacture conveniently and promptly practically all power-house and sub-station equipment required for 25-cycle apparatus. The weight of this consideration, however, is somewhat lessened by the fact that the march of progress,—just now greatly accelerated by the general adoption of steam turbines,—will undoubtedly cause a large proportion of existing drawings and patterns to be superseded probably in the very near future, and certainly within the next five years.

3. The 25-cycle is preferable to the lower frequency in the design of turbo-generators, since it affords a wider range within which to select the speed for units of various outputs. For very large units a frequency of 15 cycles, for example, requires either a 2-pole generator operating at 900 revolutions per minute, a 4-pole generator operating at 450 revolutions per minute, or a 6-pole generator operating at 300 revolutions per minute. Reductions in the number of revolutions per minute implies increase in diameter of the revolving element of generator and turbine, and in machines of large output the diameter of the revolving element in turbines of certain types may become too large for shipment, in view of the limitations imposed by tunnels.

4. A frequency of 25 cycles permits convenient and effective lighting of yards and shops by incandescent lamps. It is also more favourable than a lower frequency as regards operation of induction motors for shop purposes.

Should our railways in general be equipped for electric operation, it is to be expected that in many cases they would undertake to supply electricity for light and power purposes beyond their own requirements, and the higher frequency possesses important advantages with reference to such commercial service.

For lighting and general power purposes in cases where it is requisite that service for lighting purposes shall be thoroughly satisfactory in respect to voltage, regulation and continuity, commercial supply at 25 cycles would be preferable. Through the interposition of motor-generator sets or rotary converters in combination with storage batteries in such cases either frequency is applicable.

5. The higher frequency possesses some advantage in respect to the ratio of tractive effort to weight upon drivers. The best information available to date appears to indicate that the difference between 25 cycles and 15 cycles in respect to this consideration probably approximates 10 per cent. Further data from actual test are desirable, and must be obtained before it is possible to estimate closely the weight of advantage possessed by the higher frequency.

6. The higher frequency is preferable for induction motors in railway service requiring a considerable range of speed adjustment. The force of this consideration depends upon the probability of using induction motors for traction purposes, and applies not only to the excellent three-phase motors, such as are in very successful use upon the Valtellina line, but also to the single-phase induction motor, which, perhaps, is not beyond the

range of probability. It is probable that in any general electrification of our railway system induction motors will play a part by no means unimportant.

Without attempting detailed discussion, it is evident from the foregoing brief statement of the more important considerations in favour of 25 cycles that extremely weighty reasons must exist if the adoption of a lower frequency, e. g., 15 cycles, be justified.

Consideration of the facts now available, however, led the authors to conclude that notwithstanding the number and force of the arguments in favour of 25 cycles, a frequency of 15 cycles was preferable, and should be adopted for heavy electric traction. The fundamental and, as it would appear, controlling reason which led to this conclusion was the fact that, within given dimensions, a materially more powerful, efficient and generally effective single-phase motor could be constructed for 15-cycle operation than is possible if 25 cycles be selected.

Final decision of the question whether the advantages of the 15-cycle motor, as compared with the 25-cycle motor in respect to dimensions, weight, efficiency, power factor and commutation, are such as outweigh the many and important considerations which favour the higher frequency, required more complete data than the authors have been able to secure up to the present time. That the difference is material, however, is established not only by general theoretical considerations of the effect of a reduction in frequency upon the design and performance of single-phase commutating motors, but also by the following facts:—

1. In the case of multiple-unit equipment of passenger cars where locomotives are dispensed with and motors carried upon the car trucks, it is very important that the dimension of motors be reduced to a minimum. Cars weighing, say, 35 tons without equipment and operating on straight and level track at speeds of from 60 to 70 miles an hour, require but two motors, except as it may become necessary to employ four motors by reason of lack of sufficient clearance at cross-overs. The difference between a two-motor equipment and a four-motor equipment in such a case approximates $2500 per car, besides which the four-motor equipment adds materially to weight, practically doubles complication, and, for both of these reasons, increases cost of operation. The difference between the dimensions of a 15-cycle and a 25-cycle motor may easily be the controlling consideration compelling the adoption of the four-motor equipment.

2. In the application of single-phase commutating motors to locomotives in general railway service, the minimizing of motor dimensions is, perhaps, still more important, although in this instance the limitations imposed by the space available are less obvious.

High-speed passenger locomotives at least should be gearless. For any assumed limits of weight per axle and length of wheel-base that frequency is preferable which permits the construction of a motor which will exert the greater pull at the draw-bar, provided efficiency, commutation and power factors are substantially equal.

Those who are engaged directly in the design of single-phase motors are probably in position to contribute to the discussion of this paper data which will throw much light upon the subject; but it would seem probable that, within given limits of dimensions, 15-cycle motors would materially surpass 25-cycle equipment in this respect. The authors were inclined to this opinion notwithstanding the probable advantage of 25-cycle equipment as regards the ratio of effective draw-bar pull to weight upon drivers.

3. There can be no question of the superiority of the 15-cycle motor in respect to the very important features, commutation, efficiency and power factor. Efficiency is obviously and directly important. Power factor affects the efficiency of the entire system, from the motor to, and including, the generator. Commutation, in view of the large and expensive commutators and the brush complication of this type of motor, is of great importance.

In order that the question raised may be looked at in proper perspective, the following estimates, based upon foregoing calculations, will be useful:—

For the equipment of the entire railway system of the United States as now existing an aggregate power-house output capable of supplying continuously 2,100,000 kilowatts would be required. Of the electric apparatus installed in the power houses, a change in frequency affects the generators, transformers, and a large proportion of the measuring and indicating instruments. It also affects the cost of the engine or turbine employed to drive the generator. At 25 cycles the apparatus affected by frequency should cost approximately $30 per kilowatt. At 15 cycles it would cost on the average perhaps $35 per kilowatt. Cost of sub-station transformers would be increased approximately one-third, and, in round numbers, the total cost of turbines and electrical power-house and sub-station apparatus would be increased from $70,000,000 to $80,000,000.

If it be assumed that one electric locomotive will do the work of two steam locomotives, about 24,000 electric locomotives would be required to take care of the present railway business of the country. Assuming the cost of the average electric locomotive to be $25,000, the aggregate cost of locomotives required would be $600,000,000. Allowing for the increased cost of the 15-cycle transformers, it would seem that the difference in cost of the average locomotive should be not less than $1000 in favour of the lower frequency, or for 24,000 locomotives, $24,000,000. This is more than twice the estimated difference in cost of power house and sub-station equipment.

It seems entirely safe to say, therefore, that the aggregate first cost of electric equipment and of steam turbine will be decreased by a change from 25 cycles to 15 cycles. The operating cost will obviously be decreased very materially. At least three-fourths of the above estimated cost of electric locomotives, say $450,000,000, represents cost of electric equipment. It will be seen, therefore, that of the apparatus which our electrical manufacturing companies may be called upon to furnish, more than 85 per cent. is rolling stock. Obviously, any argument in favour of 25-cycle equipment which may rest upon existence of drawings and patterns and convenience in manufacturing should have comparatively little weight.

The use of 15 cycles instead of 25 cycles also secures considerable advantage in respect to the overhead trolley conductor and track return. With a given limit of voltage-drop, this advantage may be utilized by reducing size, and, consequently, the cost of the overhead copper and the copper used to reinforce the track return.

Under the plans which were assumed as a basis of the calculations, the amount of copper required for feeder circuits, trolleys and reinforced track-return, estimated at 20 cents per pound, would cost approximately $750,000,000 were the entire railway system of the country, as existing in 1905, to be equipped for electric operation.

In all the estimates 0000 copper has been included in the return circuit, this being bonded to the rails at intervals for the purpose of preventing dangerous potential on track in case of a broken bond.

DISCUSSION

In the discussion following the reading of the paper, Frank J. Sprague said that urgent business had prevented him from reading the paper thoroughly, so that he would not discuss it. Briefly, he said, the authors had given an interesting resumé of statistical information based almost entirely upon direct-current operation. They had generalized the features of operation of the steam railroads of the United States, and on that generalization had formulated certain general ideas. Their plea was for standardization of electric railway apparatus, and for a standardization along the lines of operation, 11,000 volts, alternating-current trolley at 15 cycles. He had ventured a few prophesies; these prophesies are now history. The authors asked where, ten years from now, will the 600-volt, 1200-volt or 1500-volt trolley be. They will be right here, said the speaker; just where the 500 and 600-volt operation of the past nineteen years have been. He did not believe that the modest work which is being done to-day by those who are actively developing the higher tension direct-current work was appreciated.

He did not find it necessary to come to any conclusions on the electric railway business, to generalize all the railroads of the United States. There were many of them in the hands of receivers, and some of the others ought to be. They could not be taken out of the hands of a receiver if they were electrified, and could not raise the money to be electrified if they wanted to be. He preferred to deal with the living, immediate question. There are now three great trunk line railroads in New York City, or terminated in New York City, to say nothing of those terminating in Jersey City and elsewhere, which in the near future will be electrified. One of them was developing electrification along certain lines, and the other on somewhat different lines. There had been considerable discussion as to the wisdom of both. Leaving these two out of consideration, did we need to look for a typical trunk line division further than the third road, the Pennsylvania from New York to Philadelphia? He would eventure not a prophesy, but a statement. If that line were called upon to be electrified to-day, it would not be, in his judgment, overhead, single-phase, alternating-current equipment, whether 25, 15 or 1-cycle. It would be a half cycle, and the cycle would be the length of time between two runs. He would make a prophesy: that on a large number of the lines, which can, by any stretch of imagination, be considered as subject to a reasonable prospect of electrification, 1200 or 1500 volts would, on any present development known, give better results in every way than the alternating-current 15 or 25-cycle overhead system.

He had spent four months in a close study and analysis of one of the most difficult railroad problems in this country. Had he not that very week been driven to the limit in trying to complete that investigation, he would have been in a better position to have done the authors more justice in criticising their paper. He hoped, however, in the comparatively near future to present to the Institute a few comparative statements on the subject of direct-current and alternating-current operation.

The next speaker, B. G. Lamme, confined himself to the question of frequency alone. Back in the early times of alternating-current work, 133 cycles per second was the common frequency. About 1889 or 1890 Mr. Stillwell, in going over the problem, saw that the larger work which was coming called for a lower frequency, and he was one of the strongest advocates in adopting 60 cycles as against 133. A few years later, in connection with the Niagara Falls first large generating station, the question of a still lower frequency came in, and Mr. Stillwell practically made the decision in favour of 25 cycles. At that time it was considered that the development of street railway work, and the use of rotary converters in such work, was such that it was more economical to use the lower frequency.

He now comes forward with 15 cycles for heavy railway work on the basis that the field is going to be large enough to call for a new and more suitable frequency. It seemed to the speaker also that, considering the total amount involved in the electrification of the railroads of this country, about $1,500,000,000, the problem was big enough to call for a frequency best suited for the work. The question is whether that should be 25 cycles or something lower. Over four years ago he had presented a paper before the Institute in which was described the Washington, Baltimore & Annapolis single-phase railway, and the frequency given was 16 2-3 cycles, a ratio of 2-3 to the standard frequency of 25.

There were certain reasons for adopting that particular frequency, although 10 per cent. higher or lower would not have been of very great importance, as far as the operation of the apparatus was concerned. It was found at the time that there was considerable opposition to the use of lower frequency, principally because most of the projects presented involved existing power plants, or it was necessary to tie the new plant to existing power plants. The projects were also relatively small. Commercial conditions practically forced them to begin at 25 cycles.

However, he still advocated the use of lower frequency when it came to heavier work, as in his discussion of single-phase railway apparatus at the American Institute meeting at the St. Louis Exposition in September, 1904. At that time he had said that the heavy railway electrification was of sufficient importance to warrant the use of low frequency which is most suitable for such work, independently of any frequencies already in use. He still held to that opinion.

The strongest reason which could be given for the lower frequency was the greater output that could be gotten from a given motor. For instance, with a first-class motor built for 25 cycles, the operation might be above question, the machine might be considered perfect in its way, but if the same machine be operated on 15 cycles, the induction could be raised from 25 to 40 per cent., which meant that 25 to 40 per cent. higher voltage could be applied with the same motor speed, and 25 to 40 per cent. greater output obtained from the same motor, or 25 to 40 per cent. greater tractive effect developed. That in itself was a controlling feature in the question.

It had been verified by actual test. For instance, from a 100-H. P., 25-cycle motor, 125 H. P. was obtained at 15 cycles. This motor had good efficiency, good power factor and good commutation on both frequencies at the ratings given. It was, therefore, not a question whether the 25-cycle motor would work, for it did work successfully, but it was a question of how much more could be gotten out of it by going to the lower frequency.

It might be questioned that if 15 cycles were better than 25 cycles, why was not still lower frequency recommended? The answer was that at 15 cycles the machine could be practically saturated, which practically fixed the output. At still lower efficiency a gain would be made in efficiency and power factor, but not much in output, and a loss is met in other things, such as the speed of turbo-generators and weight of transformers. There was some point at which a compromise could be made, and it was the speaker's opinion, and had been for a long time, that this compromise was considerably below 25 cycles, and should be about 15 cycles. The increased output obtained from a motor at the lower frequency was of advantage principally in getting a smaller number of motors under a locomotive or car, which directly cheapens the cost; or, on a locomotive, keeping the same number of motors, a bigger output is secured for a given weight of locomotive.

But there are some cases where we do not gain much by the use of lower frequency. For instance, where it is necessary to operate a. c. d. c., requiring four motors in order to obtain series-parallel control, in most cases the full gain from the use of 15 cycles is not had, for the number of motors cannot be reduced. That is one of the conditions met in the New Haven Railway equipment, for the direct-current operation on the New York end requires the use of four motors. There are many cases where the power is purchased in which it is necessary to use the higher frequency. Of course, the results are obtained at a somewhat lesser capacity or at an increased cost.

One point which Mr. Stillwell had not touched on was the fact that the single-phase series motor could be made to operate on both 15 and 25 cycles; for instance, a 25-cycle motor will operate very well at 15 cycles and at practically the same speed, because the speed has nothing to do with the frequency, and a 15-cycle motor, if well-designed, will operate on 25 cycles fairly well, at its normal capacity, but at slightly reduced capacity, so that if a locomotive should be equipped with transformers suitable for operating at 15 cycles, for instance, it could operate on both 25 or 15 cycles very well. By taking a 25-cycle equipment, nominally designed for 25 cycles, and putting 15-cycle transformers on it, the equipment is adapted for operation on both 25 and 15 cycles. That is important in connection with the fact that 25 cycles will have to be used in a certain number of cases, but in other cases where the generating conditions can be made suitable 15 cycles will work to better advantage.

The paper mentioned some of the advantages of the higher frequency, one of which was the better ratio of tractive effort to weight on drivers. Tests had been made at East Pittsburg on electrical locomotives at both 15 and 25 cycles, and it was very difficult to determine any difference in the ratio of tractive effort to the weight on the drivers. In some cases the tests were possibly in favour of 15 cycles, and in others in favour of 25, and the difference was probably no more than would be found in making two consecutive tests in any one frequency. If the motors are spring connected or have some flexibility between the armature and the driver, which is true in most cases, especially where they are geared, the difference in the tendency to slip practically disappears.

Bion J. Arnold said he did not agree with the authors of the paper that we should standardize at once and thereby shut out the utilization of the talent and genius of the men who were members of the Institute and other bodies in this and other countries. He was willing to concede, if the alternating-current railway systems are to be used, that it is probable that a standard frequency should be adopted, and, so far as his investigation had gone, in conjunction with work with Mr. Stillwell,—the Erie Railroad work,—his own conclusion was to lean toward the 15-cycle frequency, although he did not want to definitely stand on that now. It seemed to him that it was the frequency which would be adopted on account of the fact that to get the requisite amount of capacity between the wheels of railway machines, the gauge being limited, it was necessary to get as much motor in there as possible, and that could be done with the alternating-current type by adopting 15 cycles. It made the weight of the machine practically the same as 25, as it increases the size of the transformer, but reduces the size of the motor, and the net weight is the same, but additional power is placed on the machine, and that is what must be obtained. Not as much power is obtained on the wheels with the alternating current as with the direct current.

He personally believed that some form of high-potential overhead conductor was going to be the final solution of the railway question. He believed in the third rail, where it was applicable, but did not believe there were many places where it is applicable; in other words, he thought the legislators of this country would come to a point where they would not permit the use of the third rail, at any rate, in exposed places, and that being the case, he thought it was up to the electric railway men of this country to begin to get ready to take care of the problem when that sort of legislation came.

There were certain types of third rail which had recently been adopted which were safer than anything adopted before, but he did not think the use of the third rail in yards and under the feet of men would be adopted as the final solution of the problem.

W. B. Potter heartily endorsed the recommendation of the authors of the paper for a more perfect standardization of the systems and apparatus for railway work. One thing, however, he thought should be appreciated, and that was that standards were ordinarily secured where it did not cost anything to bring them about. An illustration might be taken with regard to the adoption of the metric system. All could appreciate how much it would mean in the matter of calculation and intercourse with European countries, but, so far, it had not been generally accepted. So far as the known systems can be considered with respect to the different problems, this must be done, so far as the railroads are concerned, from the standpoint of the cost for each individual case. One could hardly expect that a road contemplating an equipment which would cost, say, $2,000,000, for the sake of standardization and in anticipation, perhaps, of sometime effecting a juncture with some other road at some distance, would spend $3,000,000, yet that is just what it would mean. That relates particularly to the question as between different systems.

With regard to the question of frequency as affecting alternating single-phase operations, there was no question but that the motor, limited, as it is, by the space between the wheels and the car body on the clearance over the track, is the device to which all of the rest of the equipment must be subordinated in order to get the best results. A great deal would be involved in the substitution of 15 cycles for 25. It meant considerable increase in cost for the generating apparatus, a frequency that would not be suitable for lighting the cars, and a frequency which for every other use than the single-phase motor itself, and incidentally the conductor system from the generating station to the motor, would possess no advantage.

He did not think, however, that we could look for the ultimate development of the single-phase motor on 25 cycles. It was true, a motor could be built that had good commutation, but it had a relatively small output for its size, weighing something like 25 per cent. more than the direct-current motor of corresponding capacity. With 15 cycles, with the same degree of commutation, the motor would probably weigh from 10 to 15 per cent. more only. The efficiency and power factor would both be very much the same.

The question of 15 cycles is one which he thought would have to be considered with respect to some given problem, but it did not seem to him that 15 cycles alternating current, or 25 cycles alternating current, or 1200 volts direct current, or 600 volts direct current would be required by anybody, any particular one of them, as suitable to meeting every case. Some reference had been made to the high-voltage direct current. With regard to that type of equipment, and also with regard to the 600-volt, direct-current motor as well, he would say that motors were possible in the ordinary direct-current type which were quite beyond the other motor as we commonly know it.

We have always looked upon the commutator of the direct-current motor a good deal as a buzz-saw in a sawmill. By the addition of the commutating pole to the ordinary direct-current motor, that is, building the ordinary direct-current motor magnetically of the same character as the single-phase motor, sparking at the commutator may be said to be eliminated. For instance, a 600-volt motor can be run at 1000 or 1200 volts without showing any sign of arcing over or sparking. A 1200-volt motor would have reasonably the same margin, so that, so far as commutation is concerned, there had been an improvement made in the direct-current motor that was comparable to the advance made when the carbon brush was substituted in place of the copper brush.

W. S. Murray thought the most interesting feature of the discussion was the question of standardization. He was inclined to believe that the word standardization looked to be a good deal larger than it really was. He did not think the Interstate Commerce Commission reports a fair basis to be a determining factor as to the establishment of standard frequency. The Interstate Commerce Commission report would include all the trans-continental lines, and there was no question but that those lines which have been unassailed yet by electricity could be electrified upon a basis a very great deal cheaper upon the low frequency than upon the high, but he did not think that should have any influence. That was a misleading factor. It must not be forgotten that the electrification now being considered was in the Eastern section of this country. It was possible that all might see a trans-continental road electrified. He thought it doubtful, and did not think that ought to have any influence in the consideration of standardization. We must think of the fixed charges that have not been taken into account, namely, in the Eastern section of the country, where it will be necessary to re-equip all these plants and operate upon what may now be termed a standard frequency of 25 cycles. For transmission and power 25 cycles was very nearly to standard; the time element involved was the major consideration of our standardization. Our fixed charges could alter, be replaced by a proper depreciation, and after having taken care of those plants that are now operated on a 25-cycle basis by that depreciation, then greater data would be at hand to decide which is the standard frequency. The frequencies in operation could be interchanged just as well as the exchange of a station with a different design. It could be done. He had not the time to go into the detail, but thought any engineer could understand what it was to change the operation of any locomotive, so he was in favour of having more data, and in letting the future consideration of that data decide it for us.

O. S. Lyford said the great question was, Can steam railroads be operated more economically by electricity? The three items which he presumed might raise the greatest doubt were repairs and renewals of locomotives, engine and roundhouse men, and fuel for locomotives, or in the case of the electric work, the cost of power at the power house. He would not discuss these different items in detail, but would like to point out the fact that these items might be doubled and still the electrical operation would not cost more than the steam. The advantage to be gained by electric traction resulting from increased facility and increased loads which could be hauled had not been capitalized. Those who had had occasion to study different specific problems had found the adoption of the electric traction, if a high-voltage trolley were used, would in no case mean an operating cost greater than the cost of steam, and in practically every specific case the saving was considerable. In allowing for the advantage gained by increase of service, which was made particularly important this time and had been strongly emphasized by John J. Hill, the necessity, in other words, for getting more service out of our existing tracks, we at once appreciated what can be accomplished. It seemed to the speaker that engineers ought not to go into too much discussion of the detail, but to place emphasis on that one great fact, that almost every specific case that could be presented bore out the conclusion of the paper, which was based on the problem of the United States as a whole, namely, that electric traction could be adopted with great advantage by the railroads.

Each one of the speakers, said A. H. Armstrong, had used his own individual method of stating the same thing,—that we had in the electric locomotive a piece of apparatus doing work that could not be accomplished by the present steam locomotive. We had outgrown the days of a piece of apparatus having an indicated horse-power capacity under 2000, having a maintenance charge of 8 or 10 cents per locomotive-mile under the best level track operation, and double that when the conditions are adverse, and we now had a piece of apparatus that under an endurance test of 50,000 miles had a maintenance charge of less than 1.5, had a concentrated horse-power of 22,000, and capable of giving 50 per cent. increase for unlimited periods with forced ventilation. He believed that with the asset had in the electric locomotive the day had been reached when big problems in railroading could be approached with supreme confidence of winning out over the steam locomotive.

It was not a case of types of apparatus, or a question of frequency. Each case had to be considered by itself. In ten years from now we would still be disputing over the question of frequency, alternating-current or direct-current operation. Looking back on the history of the steam locomotive, we had no standard. Representatives of the different roads, the master mechanics and different engineers, had their own ideas about various matters in connection with their locomotives, and the meetings of our steam railroad engineering clubs have the same lack of agreement.

The locomotive, as turned out by the electrical engineer, provides opportunity for doing something that cannot be accomplished by steam. This point had been well illustrated in the past by the entire elimination of the steam locomotive in our city work and short-haul suburban work. It was being demonstrated in the big terminal electrification now going on around New York City that the electric locomotive can do something that cannot be accomplished by the steam locomotive.

In our Western mountain sections there is going on at the present time very careful consideration of the substitution of electricity for steam, solely based upon one reason, that such roads are in need of a type of locomotive which can surpass the best performance of the steam locomotive as constructed to-day or as foreseen in the future. A steam locomotive having a capacity of 500 tons trailing on a 2 per cent. grade is going to be a thing of the past when the work can be done with an electric locomotive that would give double speed and haul double the trailing tonnage. In the face of such facts it is futile to discuss such details of construction as frequencies and types of apparatus when the main question taken up by the paper is the substitution of the electric motor for the steam locomotive.

It seemed to N. W. Storer that the whole question of the electrification of steam railroads came down to one of dollars and cents, and a system which could be operated and installed for the least money was going to be the one to win out. His experience was that it generally came down to the question of a locomotive of the single-phase type. They had considered the direct-current locomotive and the three-phase locomotive, but it did not seem that either one of these was the type of locomotive which would meet the requirements of the railways in this country. The direct-current locomotive, as it had been designed, certainly will not do it. The single-phase locomotive seemed to offer the greatest possibilities. The question of frequency was most important. Every time the single-phase locomotive came up for heavy work, it very quickly brought up the question of frequency, and it always, or nearly always, worked down to 15 cycles, or so it had been the last few months. Larger motors can be had within a limited space, and at least 30 per cent. greater output could be obtained from motors with 15 cycles than with 25 cycles. The question of efficiency alone is bound to influence the matter very largely. The 15-cycle motor approximates very closely the efficiency reached by the direct-current motor, and there is so little difference in it that one can hardly detect any difference. In power factor it comes very close to the direct-current motor. The question of cost of locomotives was mentioned,—the saving in cost which would be expected by using 15 rather than 25 cycles,—and he was bound to say that the difference shown in the paper was entirely inadequate to cover the difference. At least $5000 would be the difference, rather than $1000. That would make a difference overwhelmingly in favour of the 15 cycles, being due largely to the increase of the number of motors.

The question of lighting the cars had come up. In regard to this he would say that very satisfactory lighting could be had with 15 cycles by using a low-voltage lamp with a heavy filament.

William McClellan believed firmly that the solution of the railroad problem was going to be by means of the 11,000-volt overhead trolley, alternating-current, single-phase system. In spite of the fact that a heavier motor for the power developed was necessary, in spite of the fact that the sub-station was divided into pieces and carried around, making a large amount of ton-miles in the course of a year, as a whole, the system provided a better solution for the trunk line electrification than any other that had been in sight until the present time, particularly if engineers could be brought to think that 15 cycles was better than 25, and he, for one, after a very careful examination of every argument, felt sure that absolutely nothing stood in the way of the standardization of this frequency.

As to the question of standardization, although the steam railroads have not standardized as to details, they have standardized so that they can exchange cars, and steam railroads should never be electrified as a whole until things are fixed, and this should be done right at the start, so that one railroad could exchange cars and equipment with others. If we could not exchange cars it would be absolutely impossible to electrify the railroads of this country, particularly on the wholesale scale that Mr. Stillwell had suggested in his paper.

W. I. Slichter had been particularly interested in the discussion of frequency, having studied that subject for 15 and 25 cycles, for single-phase work. He thought there was no question but that the lower frequency was very desirable for the single-phase motor. There seemed to be a unanimous opinion that the output of the motor might be increased about 30 to 35 per cent. by a decrease in frequency to 15 cycles. This would, in many cases, make it possible to build a motor of sufficient power, in the limited space available on the trucks of a car, to obtain the results desired, whereas at 25 cycles it would be impossible; but we must, as Mr. Stillwell had pointed out, consider what it would cost.

The other parts of the system, except the transmission itself, were affected in the reverse way. In considering first an interurban road in which the number of equipments operating were small compared with what would be considered on a large steam road, as discussed by the authors, the speaker found that for 25 cycles the cost of the power house was 34.5 per cent. of the total, sub-stations 2 per cent., low-tension construction 14.8, low-tension copper 12, high-tension 5.4, bonding 7, and equipments 25 per cent.

With 15 cycles, the power house cost was increased to 38, sub-stations to 2.1, low-tension construction remaining the same, at 14.8, and, due to the lesser losses in the track, the copper could be decreased to obtain the same losses to 11 per cent.; the high-tension construction remained at the same, 5.4; bonding the same at 7, and the total cost of equipments 23, making the total 1 per cent. greater for the 15 cycles. But changing the scene to a road which approximates steam railroad practice, in which the cost of the equipments was increased approximately 100 per cent., with the cost of the power station a proportional increase, the figures come out quite otherwise, and very closely as given in the paper, which showed that as heavy railroad work is approached there will be more demand for the lower frequency.

In figuring these costs, Mr. Slichter had found that a great deal depended on the design of the generating station. The generator itself might increase in cost from 15 to 50 per cent. This was due to the fact that the speed of 15 cycles was going to be somewhat of a problem in connection with turbine work, whereas with slow-speed, engine-driven units it was not so much of a problem. It could increase the transformers by 20 per cent., and bring about a decrease in the distributing system of 10 per cent.

One point that had not been discussed was that, although the output of the motor had been increased 35 per cent.,—the output during acceleration,—the continuous output of the motor was not correspondingly increased, and for passenger service, with long runs and lesser acceleration, not so much was to be obtained by the lower frequency.

In concluding the discussion, Mr. Stillwell said he believed that the great majority of engineers present would admit that the question of frequency was settled decisively by the testimony in favour of 15 cycles of Messrs. Lamme, Storer and Slichter.

They had testified that the difference in favour of 15 cycles, as measured in draw-bar pull, was very great. When that fact is taken into consideration, in view of the general perspective of the problem which the authors had endeavoured to consider, the electrification of the country, as a whole, it seemed to him that there was only one conclusion to draw.

In the estimates the authors calculated that the expenditure for rolling stock on the 25-cycle apparatus would be $450,000,000. Mr. Storer had said that the difference in favour of the 15 cycles would be at least $5000 per locomotive. Scaling that down to $4000, and applying that to 24,000 locomotives, the difference is $96,000,000, which is ten times the difference in cost of power house equipment. He believed it possible to standardize frequency and the difference of the position of the overhead trolley. That certainly ought to be done. The steam railroads had standardized everything in relation to the interchange of their traffic. That precedent must be followed, or all sorts of trouble will result.

Mr. Sprague had explained why he had not the same kind of station that Mr. Murray had. When they met at Albany, after having electrified the systems further back into the country, they would have some difficulty in making their systems fit, and that was what was to be avoided.

The meeting then adjourned.

The Helion Filament Incandescent Lamp

By Prof. H. C. PARKER and WALTER G. CLARK

The Helion incandescent lamp, which was described recently in a paper before the American Physical Society, is the result of several years of research work on

FIG. 1.—A BROKEN FILAMENT OF A HELION LAMP WHICH FUSED AGAIN WHERE THE PARTS CAME IN CONTACT

the part of the authors in the Phœnix Physical Laboratories of Columbia University. The name Helion is adapted from Helios, and was adopted on account of the resemblance of the spectrum of the light from this filament to the solar spectrum.

In some respects the filaments are quite remarkable, as they are not metallic, yet they can be operated at a specific consumption of one watt per candle at a temperature which readings on the Fery absorption pyrometer indicate is very much below the temperature of metallic filaments when operated at this consumption. The Helion filament is composed largely of silicon, which is reduced and deposited, together with the other materials, under very exact conditions. The base which is being used at present is a special carbon filament, on which the necessary deposit is made. The filament is mounted within a globe which is then pumped out, much the same as with the ordinary carbon lamp.

When current is applied, the first noticeable characteristic is the white light radiated from the filament at a current density at which the carbon filament would be radiating only red rays. The next characteristic is the whiteness of the light and the high luminous efficiency of the filament at its normal current density, and next the overload or extra current which it will carry without breaking down.

The filament, while not metallic in the proper sense, shows a metallic characteristic in that it is possible to fuse parts of it together very much the same as is done with a metallic filament. This is demonstrated by the filament shown in Fig. 1, which broke, and then fused together where the parts came in contact.

In early experiments with the filament it was noticed that a point of maximum candle-power could be reached, and that further increase in current apparently did not result in a proportional increase in light. This has been borne out by pyrometer measurements, which are shown on the curve in Fig. 2. It will be noticed that the candle-power increases with the temperature in practically a

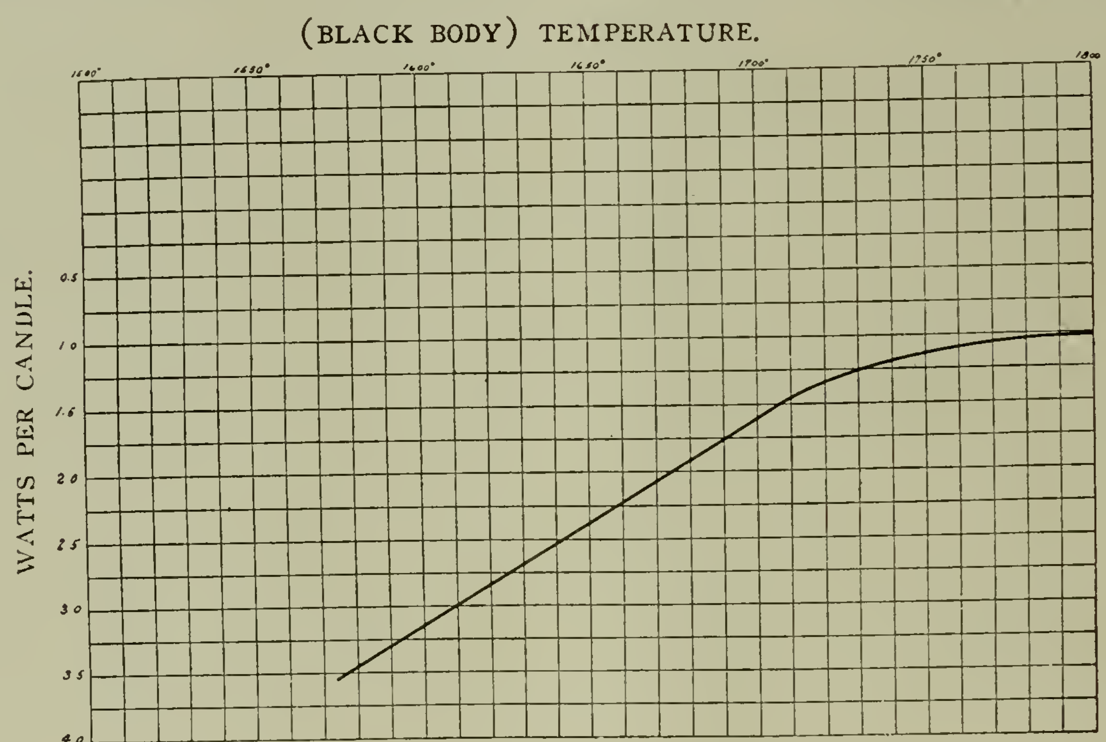

FIG. 2.—CONSUMPTION CURVE

direct ratio up to a temperature (black body temperature) of approximately 1720 degrees, at which point the curve flattens down, until it is practically flat at 1800 degrees. In some experiments to determine the overload which the filament would carry, the power applied has been increased by 100 per cent. after the point of apparent maximum brilliancy had been reached, the filament carrying the overload without rupture.

The curve of Fig. 3 shows the filament's temperature-coefficiency, which is at first negative; the resistance of the filament shown in the curve drops from 32¾ ohms at 1125 degrees temperature to 26¼ ohms at 1375 degrees, then increases to 27 ohms at 1720 degrees, and has a slight negative coefficiency beyond this point. The test shown on this particular curve was made on a short section of a regular filament.

It will be noticed that the change from the positive temperature coefficiency to a negative coefficiency takes place at practically the point at which the ratio of temperature to candle-power makes its greatest change, as shown in Fig. 2. The change occurring at this point would seem to indicate that a molecular alteration had taken place in the filament, but if this is so, it would appear that the same change occurs in a reverse order as the temperature is reduced, for when the filament is allowed to cool and power again applied, the same characteristics are observed.

The amount of overload the filament will withstand was well shown in a lamp in which long copper wires were used to place a small loop filament into the middle of the lamp bulb. The current passing through the filament was raised to a point where the copper wire on one side fused. The overload did not appear to have in any way injured the filament, which remained intact, and the only discolouration on the glass was a slight deposit of copper on the side near the fused terminal, there being no deposit from the filament on the glass, although the cross-section of the copper wire is several times greater than the cross-section of the filament.

The curve in Fig. 4 shows the relative intensity of light from a Helion filament and a standard make of carbon filament lamp at various wave lengths in the spectrum, each lamp being operated under normal conditions. The curve shown in Fig. 5 indicates the energy consumed by the same two lamps in producing this luminosity curve. It will be noticed that the Helion energy curve is the smaller one, while the luminosity curve is much greater than the carbon filament.

The greatest degree of luminosity for each lamp appears at .58 μ. This result seems to be due to some

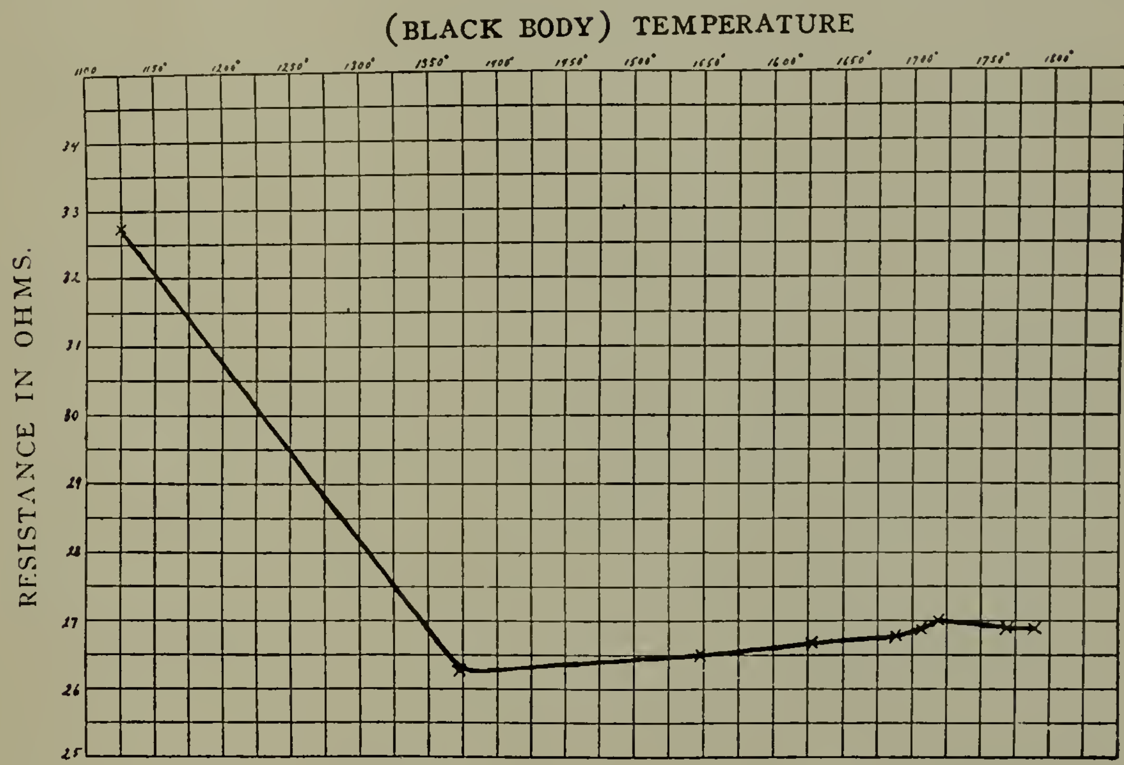

FIG. 3.—CURVE OF TEMPERATURE COEFFICIENCY

characteristic of the human eye, because a Welsbach mantle, the open gas flame, and other sources of illumination so far tried, all give a maximum intensity at this wave length, and it would appear that the normal eye is most sensitive to this wave length, which is between the yellow and the green.

Sufficient time has not yet elapsed

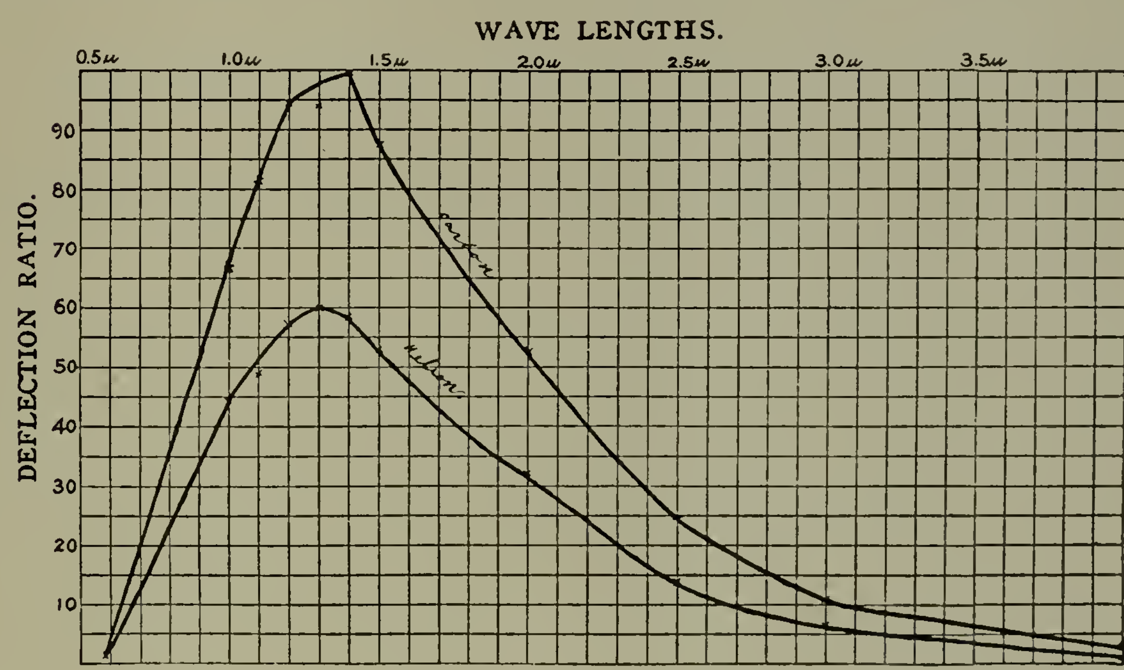

FIG. 4.—RELATIVE INTENSITY OF LIGHT FROM HELION AND CARBON FILAMENTS

to give conclusive life tests on these filaments, but out of the few tested eight lamps have shown lives of from 485 hours to 1270 hours actual burning. The lamps tested were all lamps originally made for other tests, and some of them had burned for a great many hours before being placed on the life test, and had been tested for candle-power at various consumptions, etc.

All were made, mounted, enclosed in the glass bulbs, and pumped out at the laboratory, where the facilities for mounting and pumping were not the best, so that this life test does not show as good results as will probably be secured on new lamps placed on life tests without being strained by the other tests to which these lamps were subjected.

That the life of the lamps tested was controlled to a great extent by the previous treatment the lamps had received, the condition of the terminals, and the degree of vacuum attained, is indicated somewhat by the fact that the lamp which failed at 485 hours showed a decrease in candle-power of about 15 per cent., while the lamp which ran 1270 hours showed a drop in candle-power of only about 3 per cent. Several of the lamps ran more than 700 hours and a number of them showed an increase in candle-power over the initial candle-power during some portion of the life. One lamp which ran 735 hours showed a gradual increase in candle-power, which reached a maximum of about 2 per cent.

Each lamp was started at one watt per candle-power, and the filament in each case parted either at or near the cement terminals or anchor, which indicated either a condition of strain on the filament or else that the cement acted upon the filament. In some cases it has been found that the cement which was being used at that time contained a low silicate, which combined with the filament and reduced its cross-section near the terminal, causing the filament to part at this point.

The lamp which ran 1270 hours showed rather an interesting performance. The lamp was started at 37 watts and 37 candle-power. At the end of 200 hours it began to show an increase in candle-power, which continued until the candle-power reached 40 at 400 hours, the wattage remaining practically constant at 37. At 400 hours the candle-power began to decline and again crossed the 37 mark at 500 hours. The decline continued at a very slow rate and when the last reading was taken at 1230 hours the illumination had dropped to about 35.5 candles, and the consumption was about 36.5 watts.

This lamp failed near one of the carbon terminals at 1270 hours of continuous operation. The only blackness or discolouration on the glass, perceptible to the eye, was a ring of brown colour around the lamp near the base and opposite the terminals. From observations made up to the present time, the high efficiency of the Helion filament appears to be largely due to selective radiation, as the filament reaches a maximum whiteness at a comparatively low temperature, after which an increase in temperature to the 1720-degree point increases the intensity of illumination, but does not appear to make very much change in the colour of the light; but with a carbon filament the colour and quality of the light shows a marked change as the temperature increases.

In making some comparisons with the carbon filament, they were run up in temperature to the point of disintegration, but even at this point the light was very much more yellow than the Helion filament at its normal working temperature. It has been found possible to make filaments as low as 30 candle-power for present commercial e. m. f. of from 100 to 115 volts, at approximately the same length as carbon filaments. How much smaller unit it will be possible to make is yet to be ascertained.

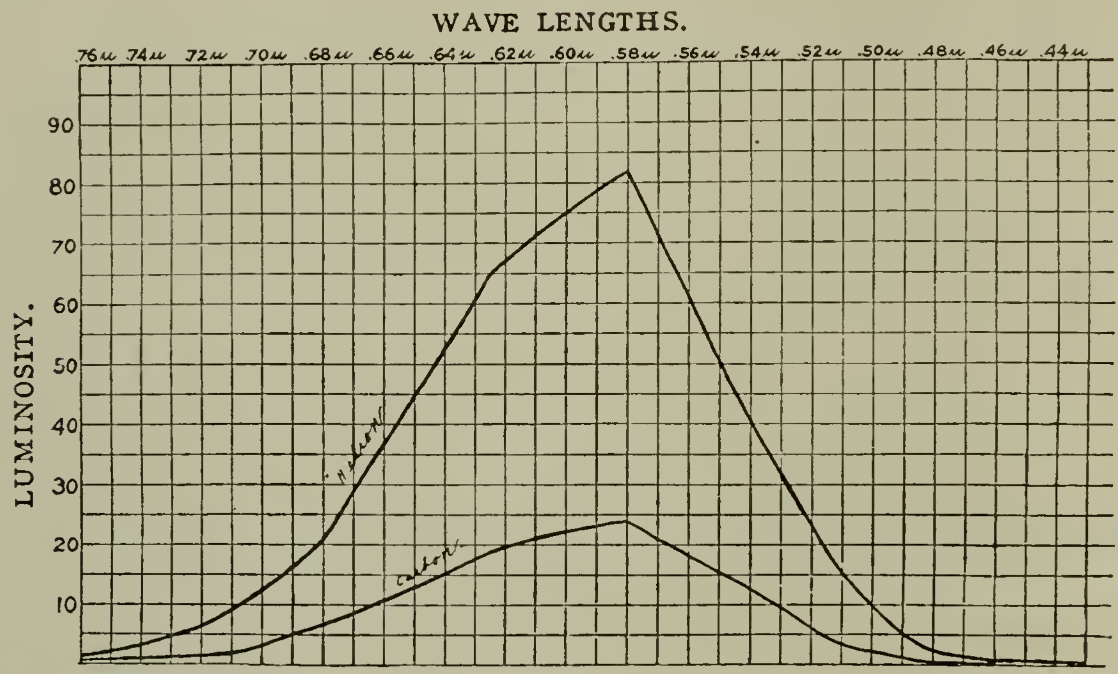

FIG. 5.—RELATIVE ENERGY CONSUMPTION OF CARBON AND HELION FILAMENTS IN PRODUCING CURVES OF FIG. 4

Review of the Technical Press

Electric Smelting for the Foundry

IN a recent letter to "Electrochemical and Metallurgical Industry," Dr. Richard Moldenke, secretary of the American Foundrymen's Association, writes of the possibilities for using the electric furnace in the foundry.

"For some time past," he writes, "foundrymen have been interested in the developments of electric smelting so far as it might be applied to their industry. As the necessary information as to whether iron may be melted in a commercial way can only be given by our electrical friends, perhaps a few remarks on the requirements involved may be of use to those who have apparatus and processes adapted for foundry work.

"The average foundryman of today has constant calls for steel castings along with his regular routine work in gray iron. This, on account of the rapid introduction of the steel casting into machine construction. These steel castings he must sub-let to the steel foundries. The latter are looking for tonnage, and do not like to fill up with small quantities of comparatively light work. Hence high prices, which cut the foundryman's profit. In a similar way, the malleable castings founder has both steel and gray iron put up to him.

"Very few foundrymen are equipped for this. They strive to place these outside lines with other people at the smallest loss to themselves. Yet if there were a convenient and easily operated process, many of them would install it immediately to take care of just such conditions.

"The smelting, or rather plain melting, of iron electrically has always seemed to me ideal in its way. We do not want to produce chemical changes in our mixtures if we can help it. We want only to melt quick, produce very hot iron, and punish the metal as little as we can.

"If, however, we could have a process which in no way changes the composition, we could put into the melt just what we want out of it, and one of the serious difficulties of foundry metallurgy would be solved. Again, if we could regulate the temperature in such a way that the iron is not overheated while melting, but can be heated up very high afterwards, we could obviate the oxidation of the metal during the melt.

"The induction furnace, it seems to me, fills these requirements, and I would like to see more work done along this line for the foundry. I may be in error, but it would seem to me that scrap of all kinds, properly selected, is all that need be melted, cleaned by some ferro-alloy, and then cast in the usual way. The enormous steel production will always yield scrap enough to supply the demand for small steel castings, once a process of this kind can be made to work commercially, and I would be very glad to be of assistance in bringing a process of this kind to the attention of the foundry world."

Inspection of Power Plant Piping

THERE is little advantage, says "The Electric Railway Review," in paying for the most economical types of engines and specifying the most expensive boiler designs, installing the most approved systems of economizers, automatic stokers, and high-pressure gravity drip apparatus with condensation returns to the boilers, if the consumption of coal is allowed to become excessive by the escape of steam or hot water from the plant through leaky boiler tubes and feed piping, loosely-jointed pipes and stop valves, or loosely-worn valves and pistons in the cylinders of engines and pumping machinery.

Where the steam is highly superheated, it is even more difficult to keep valves tight, and much is yet to be learned about the best metals for the high and low-temperature service required in valves for use on superheated lines. It sometimes happens that the leakage of a steam trap will go on undetected for weeks if regular inspections of the piping systems are not in vogue, with a resulting fuel waste which entirely offsets the supposed economy of an expensively designed plant.

It is more or less a thankless task to hunt down leaks and repair them. In most cases it would be highly profitable if a thorough examination were made every fortnight or possibly once a month for leakage. Visible waste of steam is easy to detect, of course, but the loss through defective traps and remote auxiliary piping can best be tested out by noting the fall of water in the boiler water columns when the turbines, engines, pumps, and heaters are cut off from operation and full steam pressure maintained in the boilers. Radiation and connection losses must be made up by a steady coal consumption reduced though it may be, so that actual steam leakage cannot be determined by its influence on the coal pile without going to great trouble; but the simple expedient of noting the fall of the water column,—which should remain stationary if there is no leakage,—is so easily applied that there is little excuse for its neglect in practice.

Substitutes for Copper

THE present enormous price of copper is a rather serious matter for electric roads that are compelled to install it on their feeder systems. Copper has now reached a price so high, says "The Street Railway Journal," as to make it necessary to look sharply into the question of substitutes. The two substitutes for copper most available at the present time are aluminum and iron. The former has been within the past few years extensively used as a conductor. In the earlier stages of its employment fears were expressed as to its uncertain tensile strength and lack of capacity for making sound joints. Its high coefficient of expansion also made it somewhat difficult to string.

At the present time experience has removed most of these fears. Stranded aluminum cables as at present manufactured have proved reliable, and they are now being successfully employed in many high-voltage systems. The tensile strength of such cables is about equivalent to that of soft-drawn copper, but their relatively small weight enables them to be used with a somewhat greater factor of safety. The question of joints, too, seems to have been satisfactorily settled by the use of aluminum sleeves put on under pressure, and while the joints are more troublesome to make than in copper, nothing has been heard of late of any material difficulty with them when once in place. In fact, there has been recently a considerable tendency to use aluminum for long spans on account of its relatively small weight. It is also claimed that aluminum conductors are less likely to hold sleet than copper ones, and hence are less exposed to destructive strains.

With respect to cost, the current price of aluminum is largely regulated by that of copper, since owing to the patent situation aluminum manufacture is at present a monopoly. Those competent to judge of the cost of producing it practically agree in holding that it can profitably undersell copper at any price reached by the latter metal within recent years. As a matter of fact, its market price can be counted upon to keep materially below that of copper, and the chief present difficulty is that of securing reasonably prompt deliveries. A few years hence, when the patent situation clears itself up and foreign producers of aluminum reach the American market, the effect upon the price of copper will be very considerable, and a repetition of the present situation will be well nigh impossible.

For all overhead feeder construction aluminum is surely available if it can be secured at suitable price. For working conductors and for underground cables copper has the advantage, but these uses are, on the whole, of a subsidiary character. With respect to iron or steel the case is different. The conductivity of steel rails, for example, is an eighth or a tenth that of copper. At any high price of copper, however, steel for equal conductivity is, and is likely to remain, the cheaper, particularly if, as is possible in some instances, old rails can be used for conducting purposes.

On elevated structures and in subways the location of such conductors is comparatively an easy matter, and they have been used to a limited extent. Of course, old rails are available only in relatively short lengths, generally 30 feet, and the question of joints is a somewhat serious one. Rails can be electrically well united, however, by electric or some other form of welding and even by some forms of bonding, and since a 70-pound rail has conductivity about equal to a million circular mils of copper, the fundamental economy of its use is evident even at a considerable expense for making suitable joints.

It is even possible to use such a conductor underground in a plank conduit filled with an insulating compound at a price probably considerably below that of insulated copper cable installed in a conduit. Of course, the utility of steel as a conductor is greatly limited by the difficulty incurred in attempting to use it with alternating currents, but as a direct-current feeder under favorable circumstances, steel, with copper at anywhere near its present price, deserves to be seriously considered.

Beyond all this consideration of metals lies the possible chance of relief by the use of high-voltage distribution for electric railways, and the last two years have made a prodigious difference in the conditions of economy as between loss of energy and investment in copper. The application of alternating current in railway practice may make also a great change in the existing situation. With small working conductors supplying energy over long stretches of track and fed from aluminum cables transmitting high-voltage current, an electric railway within the next few years may be far less at the mercy of the copper market than is now the case.

Peculiar Origin of an Electric Fire

THAT defective electric wiring in a building may be cause of fire some distance away or in a building where there is no defective wiring, was demonstrated in Lowell, Mass., recently, says "Electrocraft." A fire was discovered in a store early one morning and extinguished before it had caused any serious loss.

On investigation, it was shown to have started in the cellar at a point where a water pipe and a gas pipe crossed. This point happened to be directly under an oil tank, a large hole was burned in the gas pipe, and the water pipe was badly blistered. The only electric wiring in the building was for an arc light which hung outside the door. The wiring, which was exposed, proved to be perfectly clear of grounds.

The current, which was supplied by a transformer on a pole directly outside the door, was found to be cut off. The same transformer supplied current for two buildings on the opposite side of the street. It has been the practice in Lowell for the last year to ground one side of the secondary wires at every service. A ground wire had been connected to one side of these feeders at the first building on the opposite side of the street, but through an error, the ground wire was connected to the gas pipe instead of the water pipe. The service wires in crossing the street cleared the trolley wire about 4 feet, and the insulation of the wire not grounded was worn off directly over the trolley wire.

In the second building on the opposite side of the street a hole was found to be burned in a lead water pipe where it came in contact with the steel ceiling, which covered concealed electric wiring. One primary fuse of the transformer was blown, and a short while before the fire was discovered a trolley wire had broken a little farther up the street, stalling eight or ten electric cars directly opposite where the fire was.

The conclusion arrived at was that one side of the secondaries being grounded firmly to the gas pipe in the first building, the other side came in contact with the trolley wire, which was forced upwards by the number of cars under it, increasing the voltage enough to jump some weak spot in the insulation between the concealed wiring and the steel ceiling, from the steel ceiling to the water pipe, and across the street to where both pipes met, the rust on the pipes forming enough resistance to cause arcing between them, burning a hole in the gas pipe and igniting the oil-soaked wood.

A New Voltage-Regulating Device for Alternators

A NEW voltage-regulating device for alternators, designed by Chas. A. Parsons and Alexander H. Law, of England, and for which a United States patent has been granted, was described recently in "The Mechanical Engineer," of London.

The device consists of a laminated ring of iron placed between the pole pieces and surrounding the armature. This ring is wound with two coils connected together, the coils being placed between the pole tips. An alternating current is sent through the coils, which has the effect of varying the reluctance of the magnetic path through the ring. In ordinary operation the ring may be placed either on the generator or on the exciter. The alternating current sent through it may be drawn from a series transformer, the primary winding being connected in the leads from the alternator.

Under light loads the alternating current passed through the coils surrounding the regulating ring is small, the reluctance of this leakage path is comparatively small, so that a considerable portion of the main flux will leak from pole to pole by this path. As the load increases, the current through the regulating coil increases. More of this leakage flux is forced to pass into the armature, thus increasing the inductance and raising the voltage.

If the ring be placed upon the exciter the effect is the same, except that in this case changes in load on the alternator produce corresponding changes in the voltage of the exciter, and thus in the main exciting current. It has been found that where such a device is applied to the exciter magnet the inductive loss of voltage in the winding around the leakage path is comparatively small, while if applied to the main magnets it is rather great. If there are several alternators running in parallel, suitable equalizing wires may be fitted between the respective regulating coils, so as to produce the same compounding of all .

The Effect of Nitrogen on the Electrical and Magnetic Qualities of Iron

SOME particulars of the effect of nitrogen in iron on its electrical and magnetic properties are given by H. Braune in a recent issue of "Stahl und Eisen."

The electrical resistance of soft iron wire is increased by the presence of nitrogen, 0.267 per cent. of nitrogen increasing the resistance 16 per cent., or lowering the conductivity 14 per cent., while the wire is made also less tough. Telephone and telegraph wires should, therefore, contain as little nitrogen as possible. The magnetic qualities of soft iron are also greatly altered by nitrogen, which acts similarly to carbon, decreasing the magnetic saturation capacity and increasing permanent magnetism. Sheet iron for transformers should be as low as possible in nitrogen, since the bad effects are much greater than when used as magnet cores.

Laminations for Armatures

SPECIFICATIONS for sheet steel with a low aging factor for use in dynamo armatures, are given by H. M. Hobart in a recent issue of "The Mechanical Engineer," of London. The steel preferred by the author contains about 0.06 per cent. carbon, 0.01 per cent. silicon, 0.08 per cent. phosphorus, 0.5 per cent. manganese, and 0.03 per cent. sulphur. Any sheet steel showing less of impurities than the foregoing will be acceptable so far as the aging feature is concerned.

Armature cores are usually built from laminations one-half millimetre in thickness. Theoretically, sheets of different thickness should be employed in designs for various purposes, but commercial reasons justify the keeping of but a single standard. There are many cases where sheets much thicker than this could be employed with advantage, such as for the cores of rotors for induction motors.

There is not much to be gained by the use of sheets of less thickness, for this entails a higher percentage of total thickness of insulating varnish, so that the percentage of lost space will be greater. The thinner the plate, moreover, the greater will be the percentage which the skin of inferior magnetic quality bears to the total thickness of the plate. Moreover, the price increases with decreasing thickness. Departures from this standard will be more often justified when made in order to employ thicker sheets than to employ thinner.

Economies in Rotary-Converter Sub-Stations

SOME interesting facts regarding the operation of rotary converters were given recently by Ernest F. Smith, in discussing a paper on "The Rotary Converter Sub-station," read before the Western Society of Engineers by R. F. Schuchardt.

BRUSH ECONOMY

The question of brush economy, said Mr. Smith, is one of extreme importance, especially when considered in connection with the operation of a large system, such as that of the Chicago Edison and Commonwealth Electric companies. In these systems there are in operation about seventy rotary converters, and when we consider that the cost of a complete set of brushes for a rotary converter ranges from $40 for a 500-KW. machine to $180 for a 2000-KW. machine, which means that the cost of brushes only of the converters in operation in the system mentioned is slightly in excess of $4000, it will readily be seen that brush economy is quite an important subject.

This matter has been given a good deal of careful study, and by careful attention to systematic maintenance of brushes, commutators and collector rings, the life of a set of direct-current brushes has been increased until it is from four to five years at the present time. This figure includes wearing out and destruction of brushes from all causes, such as the wear on commutator, sanding, cracking due to vibrations, explosions due to rapid expansion and burning off of pigtails or unsweating of pigtail caps due to poor contact or defective distribution of load between brushes.

Considering wear and loss due to sanding only, the life of a direct-current brush is equivalent to about eight years, and considering wear only, the life would be about ten years for an alternating-current copper brush and twenty years for a carbon brush. It will thus be seen that, considering twenty years as the maximum possible life and four years as the actual life obtained in practice, the percentage of life in the Edison and Commonwealth systems is about 25 per cent. This is considered to be comparatively high.

SETTING BRUSHES

There are 430 brushes on a 2000-KW. machine and 112 on a 500-KW. machine, necessitating constant care and attention in order to keep them in prime condition. The matter of properly setting the brushes is of the utmost importance. The brush-holder studs on the direct-current side should be accurately and equally spaced all around the commutator and a line of brushes of a given polarity across the commutator should be absolutely parallel with the commutator bars. The positive brushes on the alternate positive studs should be staggered with reference to each other, so as to cover the entire commutator surface, instead of allowing the brushes of a given polarity to track and form grooves.

Experience indicates that a carbon brush tension of about one and one-third pounds per square inch gives most satisfactory service and contributes to the life of the brush and commutator. The copper brushes on the alternating-current side give very satisfactory results when the tension is from one and one-half pounds with a 500-KW. to two pounds with a 1000 or 2000-KW. unit. The current density in the contact surface of the rotary-converter brushes in use in the system referred to ranges from 27.6 amperes per square inch for a 500-KW. rotary to 33.3 amperes per square inch for 2000-KW. rotary on the direct-current end, and from 50 to 57 amperes per square inch for the laminated copper brushes on the alternating-current end.

The equivalent of one complete row of carbon brushes is treated with dynamo oil and distributed in the brush holders throughout the commutator in such a manner as to bear on the entire commutator surface. This is for the purpose of effectively lubricating the commutator, thereby reducing friction and noise in operation. The method of treatment consists of immersing the carbon brushes in boiling oil for a period of about an hour, after which they are removed and dried at a temperature of 200 or 300 degrees F. for a period of half an hour or more. The commutator surface is frequently wiped with a clean piece of cheesecloth, and when the machine is about to be shut down and is well heated up a piece of cheesecloth bearing a trace of oil is wiped across the commutator, with a clean, dry piece of cheesecloth bearing upon the commutator surface immediately back of the oiled cloth. This method of maintenance will keep the commutator and brush surfaces in good condition.

The alternating-current brushes are staggered on the ring, so as to get an even wear, and it is found with good care that it is not necessary to retrim them or seriously disturb their adjustment more frequently than about once a year. They are then properly trimmed and beveled and replaced on the machine. A very light application of vaseline or machine oil from time to time, while the machine is in operation, will effectively prevent cutting of the ring or excessive wear on the copper brushes. This treatment will preserve the commutator and collector rings in good condition, requiring the turning down of the collectors at intervals of about five years, and turning of the direct-current commutators at intervals of from five to ten years. As the cost of turning down commutators and collector rings ranges from $58 for a 500-KW. machine to $140 for a 2000-KW. machine, it will readily be seen that there is room for substantial saving by the proper care of these parts.

OIL ECONOMY

In connection with oil economy statistics show that the average consumption of oil for each machine in the system during the past year has been 3.2 gallons. This is equivalent to a life of four years for the oil. The temperature of the bearings is very closely observed with reference to the temperature of the surrounding air, and in all cases where the rise in temperature exceeds 15 degrees C. the oil is promptly filtered and replaced in the bearings. This will usually result in lowering the temperature. If the temperature still remains high the cause should be further investigated and removed.

The average rise in temperature of all bearings in the Edison and Commonwealth systems at the present time is approximately 14 degrees C., the minimum being about 7 degrees C. A portable filter is used for the purpose of filtering oil, and is sent from one sub-station to another as required.

BLOWERS

It is extremely important that the condition of the blower equipment for the air-blast transformers and regulators be properly maintained at all times, as the shutting down of the blower would seriously affect the operation of the converter units at times of heavy load, and on account of the serious overheating of transformers and regulators which would follow, it would soon become necessary to shut down the main units if the air blast were not restored.

The screens used for cleaning the air are regularly inspected and washed and blown out, and the ventilating ducts of the transformers and regulators are thoroughly blown out and cleaned from once to twice a week.

STARTING AND SYNCHRONIZING

In connection with the operation of such sub-stations, accurate synchronizing is about the most important specific operation required to be performed in a sub-station. Any serious inaccuracy in performing this operation will result in fracturing the castings of the potential regulator, or if there is no regulator used in connection with the unit, the armature conductors of the converter are likely to be drawn out of their slots or the transformer structure seriously strained.

In connection with the regular shutting down of rotary converters which are normally started from the direct-current end, it is extremely important that the field circuit of the converter should be left closed until the machine stops rotating. This is necessary in order to thoroughly demagnetize the transformer cores, and it is partially true in connection with diametrically connected units.

Under certain conditions the converter may stop with the direct-current brushes resting on the commutator bars which are connected to the same armature conductors to which the collector rings are connected, which are, in turn, connected to the terminals of a given transformer coil. This places this transformer coil in shunt circuit with the armature windings of the converter. If this transformer coil has previously been demagnetized, its impedance will be sufficient, upon throwing the starting current into the armature of the converter, to prevent an undue amount of current from passing through the transformer instead of through the armature of the converter, and the machine will start.

However, if the transformer had not previously been demagnetized and the field circuit had been opened at a time when the magnetization of the transformer coil was at a maximum in the same direction as would be caused by the passage of the starting current through the transformer coil, then there would be practically no impedance and the practical equivalent of a short circuit would be connected to the direct-current brushes of the converter, thus rendering it impossible to start the machine. In this case the brushes should be lifted from the alternating-current rings, and the transformer momentarily connected to the high-tension line, thus changing its magnetic state to a more favourable condition.

Electricity in Medicine

THE London "Lancet" of recent date contains some interesting abstracts of a paper on "The Influence of High-Frequency Currents on the Surface Temperature of the Body," read by Dr. W. F. Somerville before the Glasgow Medical Society. Patients of the author undergoing high-frequency treatment had often remarked to him that they "felt warmer" after an application, and to determine whether this was real or imaginary he had conducted a number of experiments. It was first noticed that in all patients the surface temperature varied with the individual and the locality, and on different days in the same individual and the same locality.

In patients undergoing high-frequency treatment there was during the application a rise of surface temperature ranging from 1.4 degrees to 17.4 degrees, the rise varying according to the individual, the locality chosen, the milliamperage, and the method of application. When a thermometer was placed on the forearm and another on the lower limb, the rise on the forearm was greatly in excess of that on the lower limb. After the current was switched off there was usually a fall in temperature, but it seldom returned to the original level within the next fifteen minutes.

In one case the temperature during an eleven minutes' application rose to 103 degrees on the forearm, an increase of 17.4 degrees. The patient was unable to bear the current any longer, not so much on account of the heat in the arm as because the whole limb swelled to such an extent, apparently from dilation of the deeper vessels, that the tension of the bandages and elastic bands holding the thermometers became unbearable. Immediately on switching off the current, relief of tension followed.

The rise of temperature was thought to be due undoubtedly to the action of high-frequency currents on the vaso-motor system permitting of increased peripheral circulation due to a dilatation of the deeper as well as of the superficial vessels. Dr. Somerville said they might with greater confidence employ these currents when treating patients of advanced years.

That electricity is not evoked as the sole means of cure, however, is apparent from a paper by Dr. John V. Shoemaker read before the Pennsylvania State Medical ollege. He says:

"Electricity in most cases is to be regarded only as an adjunct to other treatment. While giving the special electric application we should also give appropriate remedies to act upon the glands of excretion and secretion. Massage, exercise in the fresh air and proper diet and regulation of habits of the individual—all these are accessory agents and should be conjoined with the electrical treatment if we wish to obtain the best results. Such, indeed, is the intelligent medical use of this agent in the hands of the qualified physician. Without such therapeutic accessories electricity, like massage, is very restricted in its usefulness and tends toward charlatanism."

Switch Boxes

WHY push type switches must be enclosed in iron boxes, when used on concealed knob and tube work, is not clear to some, says "Electrocraft." There are three good reasons of about equal importance. In most cases the switch is more or less exposed to falling plaster, dirt, and the like, and the box offers a more complete protection. Again, such work is apt to be exposed to mechanical injury during the completion of the building, against which the box also offers protection. All such switches are liable to break down under operating conditions, with resulting heating and arcing. The box helps to confine this incipient fire where it will do little harm.

Owing to the great expansion of buildings of fire-proof construction and the demand of fire underwriters' engineers, and last, but not least, the humble owner of the property, for the safest and best electrical construction, it will not be many years before the porcelain "knob and tube" work will be relegated to the scrap pile. Possibly this opinion may not be accepted by everyone, but it is believed they will at least agree that "knob and tube" work will in the near future be permitted only in small towns and outside the fire limits of larger towns and cities.

The initial step in the matter has already been taken by the cities of New York, Chicago, and Washington, their ordinances covering electrical work prohibiting "knob and tube" work within the fire limits. Such action will undoubtedly be followed by other cities.

News of the Month

The Public Utilities Association of Indiana

On December 27, at Indianapolis, the Public Utilities Association of Indiana was organized by representatives from the various electric light companies in the State. The meeting was called by B. V. Hubbard, secretary and manager of the Public Service Company, of Mooresville, Ind., at the suggestion of several men interested.

The companies represented at the meeting or signifying by letter their willingness to join the association, were as follows:—

Evansville Gas & Electric Light Company, W. B. McDonald, secretary and manager; Bicknell Light & Power Company, A. L. Brocksmith, manager; Citizens' Water & Light Company, of Greenwood, J. A. Craig, secretary and manager; Elwood Electric Light Company, S. B. Harting, manager; Ligonier Electric Light Company, W. S. Draper, manager; Marion Electric Light & Heat Company, George N. Tidd, manager; Knox Electric Light & Power Company, Thomas A. Grist, owner; Clinton Electric Light & Power Company, J. W. Robb, secretary and manager; Rockport Water Works Company, A. H. Kennedy; South Bend Electric Company, F. A. Bryan, secretary and manager; Spencer Electric Light plant, William S. Mead, owner; Muncie Electric Light Company, George N. Tidd, manager; Plymouth Electric Light plant, C. D. Snoeberger, president; Putnam Electric Company, Greencastle, John G. Bryson, manager; Noblesville Heat, Light & Power Company, C. E. Layton, superintendent; Covington Light & Water Company, H. C. Yount, secretary; Public Service Company, Mooresville, B. V. Hubbard, secretary and manager; Arcadia Electric Light plant, J. A. Shunk, Peru, owner; Citizens' Water & Light Company, Winchester, C. R. Semans, secretary and manager.

Two committees were first appointed, one on organization and incorporation, consisting of J. A. Shunk, of Peru, and W. S. Mead, of Spencer, and one on constitution and by-laws, consisting of Dr. J. A. Craig, of Greenwood, and Carl R. Semans, of Winchester.

According to the constitution and by-laws finally adopted, five directors are to be elected at an annual meeting, and they will select a president, vice-president, secretary and treasurer from among themselves. Semi-annual meetings are to be held on the second Thursday in May and in December. Membership in the association is open to owners or officers of public service companies in the State.

The board of directors elected at this meeting were:—B. V. Hubbard, of Mooresville; J. A. Shunk, of Peru; C. R. Semans, of Winchester; Wm. S. Mead, of Spencer, and Dr. J. A. Craig, of Greenwood. At the meeting of the board of directors held immediately afterward, the following officers were elected:—B. V. Hubbard, president; Wm. S. Mead, vice-president; J. A. Shunk, secretary; Dr. J. A. Craig, treasurer.

Annual Election of the Western Society of Engineers

At the annual meeting of the Western Society of Engineers, held in Chicago on January 8, the following officers were elected:—

President, W. L. Abbott; first vice-president, Andrew Allen; second vice-president, E. N. Layfield; third vice-president, A. N. Talbot; treasurer, A. Reichmann. Of the electrical section, C. A. S. Howlett is chairman, D. W. Roper is vice-chairman, and P. B. Woodworth, O. E. Osthoff and K. B. Miller are members of the executive committee. The secretary is J. H. Warder, 1737 Monadnock Block, Chicago.

Limitations of Imported Niagara Power

Secretary of War Taft recently made public the extent to which the importation of Canadian Niagara power into the United States is to be limited. This action is authorized by the Burton Act, passed by Congress last June, which limits the amount of water to be taken from the American side and the amount imported from the Canadian side to 160,000 horse-power. The latter is divided as follows:—

To the International Railway Company, 1500 horse-power; to the Ontario Power Company, affiliated with the Niagara, Lockport & Ontario Company, of New York, which transmits power to Lockport, from Lockport to Buffalo, and from Lockport, by way of Rochester, to Syracuse, 60,000 horse-power; to the Canadian Niagara Falls Power Company, 52,500 horse-power, and to the Electrical Development Company, 46,000 horse-power.

Regarding the diversion of water on the American side, Secretary Taft decided that the Niagara Falls Power Company be permitted to use 8600 cubic feet per second, the Niagara Falls Hydraulic Power Company 6500 cubic feet a second, and the Erie Canal 400 cubic feet a second.

The permits granted will be effective for three years. If at the end of six months from the time of actual operation under the permits no depreciation in the beauty of the falls is shown, the permits may be extended.

The Strength of Elm, Oak and Locust Insulator Pins

At the request of certain consumers, the Forest Service of the United States Department of Agriculture recently made tests on fifty-three insulator pins of rock elm, live oak and black locust. The tests were made at the timber-testing station of the Forest Service at Purdue University, Lafayette, Ind. The results indicate the relative strength of the pins tested, although too small a number of tests were made to obtain authoritative data.

The pins were of standard size, $1\frac{1}{4}$ by 8 inches. The oak pins were from $\frac{1}{8}$ to $\frac{1}{4}$ inch shorter than the others, and of slightly smaller diameter at the shoulder. Their lever arm was also about $\frac{1}{2}$ inch shorter than in the cases of the other two species.

In testing the pins an iron block was clamped to the fixed upper head of a small screw-testing machine. The pins were inserted to a tight fit in a hole in this iron block, and projected horizontally over the pulling head of the machine. The glass insulator was unable to bear the strain of the wire, so an iron model of the ordinary glass insulator was screwed on the pin and connected by means of a heavy wire to the pulling head of the machine. When a strain was put on this wire the pin acted as a beam fixed at one end and loaded at the other, which is practically the condition met with in practice. The breaking moment (maximum load times lever arm) is taken as a measure of the strength of the pins.

The iron block mentioned was used

in preference to a wooden cross-arm for supporting the pins, for the reason that the iron block forced the pins to break under the test. Furthermore, it furnished uniform conditions for all pins. Thus the results of the tests do not show the strength of a combination of pins and cross-arm, but they show the bending strength of the pin itself.

The following table gives the results of the tests:—

Species.	Number of Tests.		Weight of Pin. Grams.	Rings per Radial Inch.	Breaking Moment (Maximum Load x Lever Arm). (Inch Pounds.)
		Avg.	106.3	12	3970
Black locust from Boston, Mass.	23	Max.	119 3	25	5380
		Min.	86 6	3	2520
		Avg.	125.9	8	4087
Black locust from Nashville, Tenn.	7	Max.	147 1	11	4930
		Min.	111.8	4	3010
		Avg.	93.8	42	2512
Rock elm from Nashville, Tenn.	8	Max.	108.7	48	3150
		Min.	77.5	33	1450
		Avg.	127 1	Not	3025
Live oak from Houston, Tex.	12	Max.	141.0	distinguishable.	4590
		Min.	110.4		1990

From the table it appears that the breaking strength of the two shipments of black locust pins was practically the same, and may be taken as 4000 pounds. Live oak pins came next in order of strength, with a breaking moment of about 3000 pounds. Rock elm pins were the weakest, having a breaking strength of 2500 pounds.

The oak pins were the heaviest, the locust next, and the elm the lightest. The locust and elm pins failed mostly by splitting from the threads to the shoulder, or by tension at the shoulder. Occasionally the portion of the pin inserted in the block failed by shearing horizontally. Nearly all the oak pins failed by tension at the shoulder.

Production of Copper in 1905

ACCORDING to the Copper Handbook, just issued by Horace J. Stevens, of Houghton, Mich., in 1905 there were fifteen individual companies each of which produced more copper than all the mines of the globe combined produced in 1805. Two mines, each of which made as much of the metal last year as all of the mines of the world made during the first five years of the nineteenth century, the two mines in question being the Calumet and Hecla, of Michigan, and the Anaconda, of Montana.

Of the fifteen mines of the globe that made twenty-five million or more pounds each of refined copper in 1905, ten are in the United States and one in Mexico, Spain, Germany and Japan, and one, the American Smelting & Refining Company, generally known as the Smelter Trust, and draws its copper ores from numerous small mines in Mexico, Canada and the United States.

In 1905 there were 183 properties credited with a production of one million or more pounds of fine copper each. Of the 100 leading producers, one, the smelter trust, drew ores from nearly all of North America, while the others were located as follows:—United States, 46; Mexico, 11; Chile, 10; Japan, 6; Canada and Australia, 5 each; Spain, Russia and Cape Colony, 3 each; Germany, 2; Tasmania, Norway, Italy, Turkey and Newfoundland, 1 each. Ninety-four of these 100 properties made more than 3,000,000 pounds of fine copper each in 1905.

A Trackless Trolley Road in Italy

FROM time to time in THE ELECTRICAL AGE has been noted the installation of trackless systems at various places on the Continent. One of the latest roads of this type is that between Spezia and Portovenere, in Italy. The route follows the seacoast, and for that reason abounds in curves, some having a radius of only 23 feet. The grades are numerous and steep.

The trolley line consists of two wires suspended 18 feet above the ground and 13.8 inches apart. The trolley used is known as the Cantono type, and it seems, so far, to have given satisfaction, negotiating the sharpest curve at a speed of 12 to 15 miles per hour.

Direct current is supplied at a pressure of 500 volts, and the motors are of 4 H. P. capacity. They are hung on the rear axle and drive the wheels by means of clutches. The controller allows of four speeds forward and two backwards, and also operates an electric brake. An additional brake mechanism is provided which may be worked by foot or by hand. Seats are provided for fourteen passengers in each car, and the lighting and heating is done by electricity.

Two cars constitute the present equipment. Each car in the present service averages about 87 miles per day, and the energy consumed, it is stated, does not exceed an average of 200 watt-hours per mile.

Proposed Electrification in the Giovi Tunnel in Italy

THE Giovi tunnel, in Italy, pierces the mountain range in the province of Liguria, and known as the Ligurian Appenines, and connects Genoa with the Lombardy plateau. The defective system of ventilation in the tunnel has made it impossible for trains to follow one another at close intervals, and thus made the capacity of the tunnel inadequate for the traffic.

For some time past electrification has been talked of, but not until recently has definite action seemed assured.

Two schemes for the conversion of the road to electric traction were laid before the Italian State railway administration a short time ago. The first contemplates the adoption of a rack rail laid between the tracks. The second recommends the employment of two locomotives which shall be capable of hauling heavy trains at a speed of 28 miles per hour.

The latter proposition has met with favourable action, and the government has requested the firms of Brown, Boveri & Co., Ganz & Co., the Thomson-Houston Company and the Westinghouse Company to submit bids for the execution of the work. The capacity of the tunnel when electrified, it is calculated, will be equal to handling 1200 freight cars of 18 tons capacity per day. For the increase of traffic above that amount, which is expected in the future, an additional line will have to be built.

Rates for Electric Power in France

WRITING under recent date from Roubaix, France, United States Consul Coleman says that the opportunities for the use of electric power in manufactories have led to the establishment of four new power plants in the city of Lille and its environs. The rates for current are essentially the same for all the companies, and are based upon a progressive decrease in cost, beginning with a charge of 3.86 cents a kilowatt-hour for a smaller horse-power and lowered to a charge of 0.965 cent and less per kilowatt-hour for subscribers, for 5 horse-power or more, utilized during a stated number of hours.

The prices given in the following

table are stated by the companies on the basis of the reckoning that the hours of utilization are equal to the kilowatt-hours consumed, divided by the kilowatt-hours installed:—

Power installed in kilowatts.	Price in cents per kilowatt-hour.			
	For the 1,000 hours of utilization.	For the 1,500 hours following.	For the 2,000 hours following.	For more than 4,500 hours.
Less than 3 kilowatts....	3.86	3.86	3.86	3.86
From 3 to 6 kilowatts.	3.86	2.70	1.73	0.96
From 6 to 10 kilowatts.	3.67	2.51	1.64	0.96
From 10 to 15 kilowatts.	3.47	2.32	1.54	0.96
From 15 to 24 kilowatts.	3.28	2.22	1.45	0.96
From 24 to 36 kilowatts.	3.09	2.12	1.35	0.96
From 36 to 50 kilowatts.	2.89	1.93	1.35	0.96
From 50 to 80 kilowatts.	2.70	1.83	1.25	0.96
Above 80 kilowatts....	2.51	1.73	1.15	0.96

Grounding Conductors for Safety

At the recent meeting at Indianapolis of the Western Association of Electrical Inspectors, a report was made by a committee on the grounding of conductors for safety. It was recommended that joints in guard wires and guard nets, for the prevention of accidental contact between high and low-potential systems, be made mechanically and electrically secure, the nets to be cross laced, the wires forming the nets to have a carrying capacity equal to the system that they are designed to protect, and be thoroughly and effectually grounded with at least two grounds having a carrying capacity equal to the maximum load carried by high-potential systems.

It was suggested that on high-potential pole lines in places accessible to the public, bands of zinc or copper be fastened around poles at a point not less than 8 or 10 feet from the ground, with bands spaced between the top band and the grade line, all to be electrically connected and thoroughly grounded with at least two grounds. This is to afford protection in cases where high-tension insulators break and allow high-potential wires to come in contact with the pole or cross-arm, and also to guard against possible static discharges over the face of insulators due to the formation of moisture or sleet. It was recommended that strain guys be thoroughly grounded and strain insulators be omitted. On arm guys, where it is not feasible to carry ground to a cross-arm, a strain insulator may be interposed, but the anchor end should be grounded.

It was also recommended that all metal lamp cables, arc-lamp span cables, police and fire-alarm call boxes and all apparatus that the public may come in contact with where there is a chance of a cross with high-potential systems, have their outside shells and cases thoroughly and effectually grounded.

Some suggestions were also offered as to grounding interior wiring. In the Edison three-wire system the neutral wire should be grounded at the point of entrance in accordance with the rules under section 13A of the supplement of the "National Electric Code." From this point the neutral wire should be carried as one solid conductor without fusing throughout the system. In other words, the neutral wire in the three-wire system, or one outside in a two-wire system, or one leg in a three-phase system should be treated as a common return.

This common-return wire would be common to every outlet, and in lieu of insulating joints where fixtures are hung on gas outlets the grounded wire should be connected to gas pipes at this point and also to the fixture shell and stem. However, it will be necessary to wire the fixtures as is required in the present system. This system of connection, as recommended at the outlet, would make the shell of the socket and the fixture stem the same polarity as the grounded side of the circuit.

The opposite side of the circuit would radiate from the junction box thoroughly insulated in accordance with the rules now in vogue, but would be protected by single-pole fusing. On installations where gas pipes are not available, ground wires should be connected to fixtures as recommended above, and at every possible point ground wires should be connected to all water pipes or any such available grounds that may be had at hand.

Considering again the grounded wire, the carrying capacity of this line must be the same as the outside wire to the center of distribution and thence on in smaller-sized wire sufficient to carry the load. No fuses or switches are to be interposed on this size of system.

The first objection that presents itself to this system is the tendency of the contractors to want to make their ground wire of bare copper. It is evident that this would not be feasible on account of subjection of bare copper to moisture and the possibility of corrosion. This wire should have the same insulation covering as is now required and joints should be thoroughly soldered and protected with insulation equal to that of the wire. However, it does not seem necessary to provide porcelain tubes where the wire passes through woodwork. However, it would not be deemed advisable to support this wire by means of staples, nails, etc., but it is recommended that it be rigidly supported on glass or porcelain knobs merely to protect it against abrasion or mechanical injury.

In conduit systems this wire would still continue to be common to each outlet and grounded to each conduit outlet available, making the conduit pipe the same polarity as the grounded wire.

Street Lighting Contract Committee of the National Electric Light Association

A new committee, just appointed by President Williams, of the National Electric Light Association, has been created for the purpose of formulating a model contract and specifications for street lighting. A great many inquiries have been made for such a contract,—one that would be fair both to the lighting company and to the municipality, and one that would permit of changes in the form of illumination, as new developments were made in the art, on a basis satisfactory to both parties to the contract.

The personnel of the committee is exceptionally strong, the members being Messrs. Dudley Ferrand, Louis A. Ferguson, Paul Spencer, Charles P. Steinmetz and A. E. Kennelly, and very happy results are looked for in the report to be presented at the thirtieth convention of the association, to be held in May or June next.

Single-Phase Traction at the Milan Exposition

One of the interesting features of the exposition recently held at Milan, Italy, was a single-phase railway, about 1600 yards in length, running between two parts of the grounds. The line was built by Godda & Co. and by Brioschi, Finzi & Co., under Dr. Finzi's personal supervision.

The installation was intended to represent the development as a result of a long series of tests made over the Valtellina line and on the line between Milan and Mussoco. The system differs from that in use in this country in that 15-cycle current is used. An auxiliary field winding was provided and placed 90 degrees with the axis of the main field coils, for neutralizing the armature reaction.

The trains consisted of four cars each, each of the cars being a motor car, though not of the same motor capacity. The first and fourth cars were provided with two motors each, but the second and third cars had only one motor each. While the speed was only 20 miles an hour, due to local limitations, a considerably higher speed could have been attained.

The trolley line voltage was 2000, the current being led into two transformers connected in series, one being placed in the first car and the other in the rear car. The secondary coils stepped the pressure down to 180 volts each, each coil being divided into sections giving a potential difference of 30 volts. The three motors of the first two cars were connected in series, as were also the three motors of the last two cars. The secondary coils of the transformers could be connected to supply each group of three motors with 180 volts, or connected in series to supply each group with 360-volt current.

The Chicago Electrical Trades Exposition

If variety of exhibits and interest manifested in them be taken as a measure of quality of the recent Chicago Electrical Trades Exposition, the success of the affair cannot be questioned. In the extent of exhibits showing the domestic uses of electricity, the show was, perhaps, unusual. That the electrical fraternity *per se* found a great deal of interest in the latest developments and inventions in electrical apparatus was indicated by the fact that many out-of-town visitors were present. In fact, the Chicago show has assumed a national rather than a local significance. The affair also assumed a larger importance because of the several meetings held during the week. The Northwestern Electrical Association met in annual convention, and a Chicago branch of the Illuminating Engineering Society was organized. The Sons of Jove also were again rejuvenated, and the American Electrical Salesmen's Association held their annual meeting.

The current for the exhibits was supplied from the Chicago Edison Company's system over temporary cables. The alternating current was supplied by a Fort Wayne motor-generator converting the 230-volt, three-phase current. The secondaries of the transformers for stepping-down the pressure were connected in Y, so that 115-volt, single-phase and 220-volt, three-phase current was available. Either meter or flat rate was charged, as preferred.

LAMPS, FIXTURES, ETC.

A most important part of the show were the exhibits of illuminants. The tungsten filament lamp was given its first public demonstration at the booth of the General Electric Company and that of the National Electric Lamp Association, and attracted no little attention. The booth of the former company was provided with a number of each type of the newer types of lamps fitted with Holophane reflectors, each row being consecutively let up by means of a flasher.

The Westinghouse interests were represented by an attractive exhibit, consisting of alternating-current multiple, direct-current multiple, and alternating series arc lamps, Nernst lamps, mercury vapour lamps, and Sawyer-Man incandescents. The Nernst exhibit consisted of six lamps of the street series type, the current being regulated by a 6.6-ampere, constant-current transformer.

Tungsten, tantalum and Gem metallized-filament lamps were exhibited by the National Electric Lamp Association. The tungsten and metallized-filament lamps were placed in electroliers on the corner and entrance posts, while the tantalum lamps were placed in wall brackets at the back of the booth.

The 25-light series alternating-current arc lamp system of the Fort Wayne Electric Works, of Fort Wayne, Ind., was exhibited by the company, a complete working demonstration being made. Other exhibits were single-phase, multiphase and prepayment wattmeters, small power motors, and fan motors.

The flaming arc lamp exhibit of Felix Hamburger, New York, showed the beautiful effects possible with this lamp. A new domestic type, said to excel the imported, was shown, and also miniature arc lamps, operating at between two and three amperes, alternating or direct current.

A 12-lamp series alternating-current arc-lamp equipment was exhibited by the Western Electric Company, of Chicago, with switchboard, transformer and regulator. The company's new "Hawthorne" type of lamp, especially adapted for low ceilings, was also shown.

The attractive array of tinted shades and globes and cut-glass domes of the Phœnix Glass Specialty Company, of New York, drew the attention of many visitors. Mandel Bros., of Chicago, exhibited an extensive line of electroliers and portables, and the Chicago Lamp & Reflector Company made a similar display. Brass art lamps and parts were exhibited by C. G. Everson & Co., of Chicago.

ELECTRIC SIGNS

A large variety of electric signs were displayed by the Haller Machine Company, of Chicago, one of them being the familiar Anheuser-Busch monogram, forming part of a 22 by 30-foot sign.

In connection with this exhibit, the Reynolds Dull Flasher Company, of Chicago, had in operation a large variety of flashers, and the Bodine Electric Company, of Chicago, exhibited a number of motors adapted to operating sign flashers, advertising novelties, envelope seals, and the like. All the lamps in this exhibit were supplied by the Shelby Electric Company, of Shelby, Ohio.

The Federal Electric Company, of Chicago, also exhibited a number of electric signs, including the panel type and the interchangeable letter type.

Electric signs and flashers were also shown by Dinsmore & Lawton, of Chicago.

DOMESTIC APPLIANCES

The exhibit of electric appliances for domestic and hotel use was unusually attractive, the display being an extensive one, and including demonstration by attendants at the Chicago Edison Company's booth. Coffee and biscuit were served, and a series of suppers were given by Frank H. Gale, of the General Electric Company, the menu being prepared by electrical apparatus.

The Simplex Electric Heating Company, of Cambridge, Mass., also demonstrated the convenience of cooking by electricity, and exhibited a variety of smoothing irons, stoves, chafing dishes, coffee percolators, and like devices.

The exhibit of the Westinghouse Electric & Manufacturing Company coming under the head of domestic appliances consisted of motor-driven dough-mixers, coffee-grinders, dish washers, ice cream freezers, plunger pumps, and refrigerating machines.

The North Shore Electric Company, supplying the suburbs of Chicago, also exhibited a variety of electric heating devices for domestic use.

GENERATORS AND MOTORS, TRANSFORMERS, ETC.

Besides the exhibit of motors driving the various machines already referred to, the Westinghouse exhibit included an engine built by the American Blower Company direct connected to a 7-KW. generator, an American Blower fan driven by a ½-H. P. motor, a motor-driven engine lathe, a saw sharpener, and a dust remover. A variety of other equipment, such as meters, railway line material, lightning arresters, transformers and small power motors, were also exhibited.

The Allis-Chalmers Company exhibited a general line of machinery, including a new 75-H. P. alternating-current generator, a 10-H. P. induction motor-generator set, a 15-H. P. high-speed generating unit, and direct-current motors from 1½ to 20 H. P. Models were also shown of the movable and stationary rings of blading of a 500-KW. steam turbine.

The single-phase repulsion-induction motor built by the Wagner Electric Manufacturing Company, of St. Louis, Mo., was shown operating a small pressure blower. Other exhibits were transformers and indicating instruments, including a combination voltmeter and frequency indicator.

The frame of a 350-KW. alternator built by the Western Electric Company, of Chicago, was exhibited by that company with a motor-driven emery grinder, and a sewing machine motor. Street railway material, including "Electrose" insulating material, were also shown. The company also showed a 45-H. P., 500-volt Ward-Leonard controlling panel in connection with a large direct-current motor.

Other motor exhibits were that of the Bidwell Electric Company, of Chicago, showing cold and self-cooling motors and generators, the cold motor being able to withstand excessive heating; Roth Bros. & Co. showing motor-driven blowers and grinders, and the Guarantee Electric Company showing the Kimble-Gregory variable speed motors.

Weston instruments, while not shown separately in one exhibit, were much in evidence in many of the booths, notably in that of the Central Electric Company, of Chicago. This company's exhibit was attractively railed in by loricated conduit, other features being a pillar of various sizes of Okonite insulated wire, various sizes and types of Columbia incandescent lamps, and a variety of fuses, cut-outs and other supplies.

The Duncan Electric Manufacturing Company, of Lafayette, Ind., presented an attractive array of direct-current and alternating-current meters. A feature which drew the attention of central station men was a meter running on a 1-candle-power lamp.

In the exhibit of the Diehl Manufacturing Company, of Elizabethport, N. J., were shown fan motors, small power motors, and sewing machine motors for domestic and manufacturing use.

"Hornberger" transformers, built by the Lafayette Electrical Manufacturing Company, of Lafayette, Ind., were exhibited by that company, a feature being a transformer showing the interchangeable ratio connections.

Two 6000-ampere, single-pole switches were the features of the exhibit of the J. Lang Electric Company, of Chicago. They are intended for the switchboard of the Congress Hotel Company's new hotel.

A current-limiting device was exhibited by the Universal Manufacturing Company, of Chicago. This flat-rate controller, as it was called, is for use in controlling the supply of the current when sold at a flat rate.

Various forms of fibre were shown by the United Indurated Fibre Company, of Lockport, N. Y. The exhibit included a third-rail covering, oil switch tanks, fibre tubes for protecting pipes against electrolysis, covers for trolley wires in mines and at crossings, automobile battery cases, and the like.

The galvanized chain manufactured by the Oneida Community, Ltd., of Oneida, N. Y., was shown in use with mast arm and arc lamp. A number of sizes for use in hanging electric signs were also shown. An attractive watch fob, an arc lamp and chain in oxidized silver, made a desirable souvenir.

The Peirce Specialty Company, of Chicago, exhibited steel structural material, consisting of brackets, and a distributing circle mounted on a 15-foot pole. The work of the Peirce banner drill was demonstrated, Peirce expansion bolts being set in the holes drilled in a block of stone.

One of the well-known Stombaugh guy anchors of W. N. Matthews & Bro., of St. Louis, Mo., was shown in position in a large box panel containing earth. Other features of the exhibit were the "Hargis" cable-splicing joint, the "Kearney" cable clamp, the "Hold-Fast" lamp guard, the "Lima" jack box and plug, "Callahan" rollers, and "O. K." slate cutters.

"Victor" direct reading instruments manufactured by the H. W. Johns-Manville Company, of New York, were exhibited with specialties, including friction tape subway and service boxes, fuses, blocks, overhead line material, and "Transite" asbestos fire-proof lining for controllers.

An interesting display of electrically-heated tools was made by the Vulcan Electric Heating Company, of Chicago. The soldering tool shown was provided with a tip of forged copper screwed into the heating head, in which was placed a resistance wire made with a special alloy.

The Holtzer-Cabot Electric Company, of Boston, exhibited a variety of specialtiess, including magneto and battery telephone bells, skeleton bells, high-voltage bells, water-tight bells, and buzzers.

The exhibit of the Ohio Brass Company, of Mansfield, Ohio, included rail bonds, overhead line material, insulators, third-rail insulators, trolley wire connectors, and bearings.

A variety of linemen's tools were exhibited by Mathias Klein & Sons, of Chicago.

Automatic motor controllers, elevator controllers, starters, and the like, were shown by the J. L. Schureman Company, of Chicago.

The character of the exhibit of the National Carbon Company, of Cleveland, makers of the well-known "Columbia" carbons, attracted a great deal of attention, several carbon columns, 10 inches in diameter, being used to support the top of the booth.

Dossert & Co., of New York, made an attractive display of their solderless cable joints.

SUPPLIES

The supply houses were well represented and made attractive displays. An extensive exhibit was made by the Central Electric Company, including Stanley-G. I. flaming arc lamps, loricated conduit, Okonite insulated wire, Columbia incandescent lamps, Deltabeston magnet wire, D. W. enclosed fuses, subway boxes, service boxes, cut-outs, transformer boxes, Edison primary batteries, and Knowles high-tension insulators.

The line of supplies exhibited by the William P. Crockett Company included Bossert boxes, diamond "H" switches, De Veau telephones, Sarco specialties, Sterling flexible conduit, Pittsburg standard conduit and Sachs enclosed fuses.

The Electric Appliance Company, of Chicago, exhibited a line of specialties, among them being Sangamo meters, Packard lamps and transformers, Stombaugh guy anchors, Sandwich pole chargers, and Paranite wire.

The Electric Service Supplies Company, of Chicago, exhibited what was claimed to be the largest insulator ever made. It was manufactured by the Locke Insulator Company, of Victor, N. Y., and it was claimed would withstand 100,000 volts. Other exhibits were an Imperial arc headlight, protected rail bonds, and a device for preventing a motorman from turning the controller handle too rapidly.

Besides a variety of supplies, the Monarch Electric & Wire Company exhibited 6000-candle-power Nurnberg flaming arc lamps working two in series.

The supply line shown by the Metropolitan Electrical Supply Company included a variety of portables, lamps, shades, including the D'Olier types, Barrett motors, Hylo lamps, and Skeedoodle socket plugs, arc lamps, Stombaugh guy anchors, fuses and cut-outs.

BATTERIES

The storage battery manufacturers were represented by attractive exhibits. That of the Electric Storage Battery Company, of Philadelphia, included a variety of cells from a tank with a capacity of 4800 ampere-hours to the cell with a capacity of 2½ ampere-hours. The "Exide" automobile cell was also shown, together with the "Exide" railway signal cell, car-lighting batteries and accessories.

The Gould Storage Battery Company, of Depew, N. Y., exhibited a 49-plate cell with a capacity of 5760 ampere-hours. Other sizes of cells were shown, and also cells for signal, sparking, and train lighting work.

The exhibit of the National Battery Company, of New York, comprised batteries for car lighting, automobile, ignition, fire-alarm and signal work.

TELEPHONES

One of the features of the telephone exhibits was a demonstration by the Automatic Electric Company, of Chicago, of a 100,000-line automatic system. The exhibit represented a part of each of two branch exchanges, eight instruments being used in the demonstration.

Telephone protective apparatus, guy clamps, clips, and a self-welding wire joint were among the exhibits of F. B. Cook, of Chicago.

A 100-line express type magneto switchboard and telephones, and a central-energy, private-branch exchange switchboard, with common battery telephones, were exhibited by the Kellogg Switchboard & Supply Company.

A large map was exhibited by the Stromberg-Carlson Telephone Manufacturing Company, to show the growth of independent companies, the various installations of the company being indicated by miniature lamps. Telephone apparatus was also exhibited.

The Swedish-American Telephone Company exhibited a full line of their magneto equipment.

Besides giving free service in the city, the Chicago Telephone Company demonstrated the better results obtained in long-distance talking by the aid of the Pupin loading coils, and the American Telephone & Telegraph Company gave full use of its lines to different parts of the country to demonstrate the perfection of its long-distance service.

A wide variety of cables were shown by the American Steel & Wire Company, including non-armoured, lead-covered, rubber-covered, and weather-proof types, and also a variety of rail bonds. Other exhibits were springs in wide variety, tools for rail bonding, and wire of every description.

Displays of conduits were made by the American Sewer Pipe Company, the Clay Products Company, of Brazil, Ind., the McRoy Clay Works, and the H. A. Peterson Manufacturing Company, of Harvey, Ill.

The Thordarson Electric Manufacturing Company, of Chicago, had an interesting exhibit, which comprised a 10-inch spark coil, a slow-speed auto-magneto, a 5-KW., 60,000-volt transformer, an electric furnace, X-ray coils and wireless telegraph transformers.

A number of portable electric tools were displayed by the Chicago Pneumatic Tool Company, including electric drills, grinders, blowers and hoists.

The Crane Company was in evidence with an arch of 12-inch pipe for the entrance to the booth in which were shown a variety of the company's valves and fittings. Special features were an 8-inch electrically operated gate valve and a 24-inch hydraulically operated gate valve with electric control.

Annual Meeting of the Illuminating Engineering Society

THE annual meeting of the Illuminating Engineering Society was held in the rooms of the Electrical Club in New York City, Jan. 14.

President L. B. Marks called the meeting to order, after which the reports of the secretary and treasurer were read. In his annual address the president spoke of the conditions in the illuminating engineering field existing before the organization of the society. While the problems of generation and distribution of electricity and gas had received careful attention, the problem of obtaining the best illuminating result was neglected.

In endeavoring to place the art on a new basis, the society had collected and placed on record much available information, and had brought together representatives of almost every field of endeavor in which the question of illumination plays a part.

Both indoor and outdoor illumination by gas and electricity had been treated. The question had been discussed from the architect's point of view and the physiological side considered. For the first time probably in history, oculists and illuminating engineers had met to discuss artificial illumination.

The type of lamp, size of unit, location and character of fixture, and kind of globe, shade, or reflector best suited to individual conditions had been studied.

During the year many old installations of gas and electric light fixtures had been modernized, and in many new installations the design and equipment had been vastly improved from an illuminating standpoint. Central stations were giving the subject more attention, employing experts in some cases. The architect also was beginning to show an interest.

One of the most important points dealt with in the papers had been the urgent need of reducing the intrinsic brightness of light sources, and particularly of such as are necessarily within the range of vision.

In the matter of lighting post-offices throughout the country, information obtained from one showed that twelve of the employees, owing to improvements in illumination, could now do without eye glasses, whereas six months ago they were obliged to wear them. The change had been due largely to removing the bright sources of light from the ordinary field of vision.

The general acceptance of definite nomenclature and standards would be of immense service in furthering the systematizing of illuminating engineering. Much had already been done by committees to bring about the standardization desired.

The president then announced the appointment of the following gentlemen as the society's international committee on nomenclature and standards:—

Dr. Alexander C. Humphreys, chairman, Stevens Institute, Hoboken, N. J.; Dr. Louis Bell, Boston, Mass.; Prof. Blondel, Paris, France; Dr. Hans Bunte, Technische Hochschule, Carlsruhe, Germany; John W. Howell, Harrison, N. J.; Dr. E. P. Hyde, Bureau of Standards, Washington, D. C.; Dr. A. E. Kennelly, Harvard University, Cambridge, Mass.; Prof. Vivian B. Lewes, Royal Naval College, Greenwich, England; Dr. Edward L. Nichols, Cornell University, Ithaca, N. Y.; Dr. F. Schniewind, New

York City; Dr. C. H. Sharp, New York City; W. D. Weaver, New York City; J. E. Woodwell, secretary, Washington, D. C.

President Marks then outlined the growth in membership of the society and referred to the organizations in Boston, Chicago, Philadelphia and Pittsburg. The society at the date of writing had 815 members, 252 in New York, 239 in Pennsylvania, 81 in Massachusetts, 80 in Illinois, 37 in New Jersey, 21 in Ohio, 33 in foreign countries, the remainder being scattered throughout the United States.

The officers elected for the coming year are as follows:—

President, Dr. Clayton H. Sharp, of New York; vice-president, Dr. Louis Bell, of Boston; managers, E. L. Elliott, of New York, and J. E. Woodwell, of Washington, D. C.; secretary, V. R. Lansingh, of New York; treasurer, Dr. A. H. Elliott, of New York.

The vote on the adoption of a new constitution resulted in 144 for and 23 against it.

Annual Convention of the Northwestern Electrical Association

THE annual convention of the Northwestern Electrical Association was held in the Coliseum Annex, in Chicago, January 16 and 17. In his address, President Harold Almert referred to the lessening public interest in municipal ownership.

The first paper of the convention was by Oliver J. Bushnell, of Chicago, on "Warrantable Expense for Meter Testing." This paper will be reprinted in a later issue.

In his paper on "Profitable Co-operation," J. Robert Crouse's remarks on the work of the Co-operative Electrical Development Association were given a good deal of attention.

The possibilities of the electrical development of Wisconsin water-powers were discussed in a paper by Ernst Gonzenbach. He suggested that the association appoint a committee to secure co-operation in obtaining for the members the enormous powers now running to waste.

The session on Thursday opened with a paper by F. W. Insull, of the North Shore Electric Company, of Chicago, on "A Uniform System of Accounting for Small Companies." The next paper, entitled "Some Phases of the Management of the Smaller Central Stations," by H. H. Scott, engineer for Henry L. Doherty & Co., of New York, brought out an interesting discussion. One of the points emphasized was that the operating cost could be reduced by getting additional business more than by any other one thing.

A paper on "Outline Lighting," by Homer Honeywell, manager of the Lincoln (Neb.) Gas & Electric Light Company, was read by W. B. Johnson, of Madison, Wis., and dealt with the advertising, sign, and window lighting in Lincoln.

"Recent Developments in Prime Movers" were discussed in a paper by Harold Almert, steam turbines and gas engines being dealt with.

A paper on "Some Characteristics of Alternating-Current Motors," by C. W. Bergenthal, of the Wagner Electric Manufacturing Company, brought out considerable information regarding single-phase motors.

J. R. Cravath discussed "Some Points on Illuminating Engineering for the Small Central Station." One of the points brought out was that as the tungsten lamp seemed to be suited for use in a pendant position only, lamp sockets suitable to a pendant now would also be suited to the tungsten lamp, whereas if sockets placed in an angle were used with tungsten lamps they would have to be replaced by the pendant form, unless the lamps were perfected so that they could be used at an angle.

"Premiums for Employees" were dealt with in an address by Ernst Gonzenbach, of Sheboygan, Wis., and a paper by A. Bement, of Chicago, discussed "Tendency in Design of Boiler Plants."

On the report of the nominating committee the following officers were elected:—

President, Edward Daniell, Marinette, Wis.

First vice-president, B. C. Adams, Lincoln, Neb.

Second vice-president, H. F. Pearce, Negaunee, Mich.

Secretary-treasurer, R. U. Kimball, Kenosha, Wis.

Directors—J. S. Allen, Lake Geneva, Wis.; W. P. Putnam, Red Wing, Minn.; George H. Lukes, Evanston, Ill.

Steel Smelting by Electricity

AMONG the many electrical devices shown at an electrical exhibition held at Sheffield, England, recently, was a small model of the Grongal Kjellin induction furnace.

This particular furnace was built to melt platinum, but during the exhibition was daily used to produce small ingots of steel, and at the close of the exhibition was taken to the National Physical Laboratory at London. A member of the Kjellin company lectured before the Sheffield Society of Engineers and Metallurgists at the department of applied science, University of Sheffield, upon the subject of steel making in electric induction furnaces.

Regarding the cost of operating, the lecturer said that the induction furnace would permit of a larger cast, a cheaper and cleaner form of melting, and reduced cost of labour. The demand for big crucible quality ingots was increasing day by day. Die ingots ranged up to two tons weight, and the quality of steel must be perfectly regular and sound. Crankshafts and axles for motor cars necessitated the use of heavy crucible ingots. With few exceptions, the crucible steel makers were confronted with really practical difficulties in making large ingots.

The induction furnace solves this problem for them, for it is as easy to make a two-ton charge in such a furnace as a sixty-pound charge in a crucible. The saving in cost was easily demonstrated. Most steel makers agreed that the cost of melting one ton of crucible steel was from £7 to £8 ($34.07 to $38.93). In the induction furnace it required 800 to 850 units to a ton of steel, and the cost in Sheffield would be from £2 to £2 2s. 6d. ($9.73 to $10.34) per ton. Two men and one boy would be able to run a furnace turning out four tons in twenty-four hours, so that the cost for labour should not exceed 7s. 6d. ($1.82) per ton.

The cost of lining, including repairs, should not exceed 2s. 6d. (51 cents) per ton; consequently the actual cost for melting one ton of steel should be well under £3 ($14.60); but if the cost was to run as high as 50 per cent. of the cost of melting in crucibles, the induction furnace had a great claim for the consideration of steel melters.

In addition to its freedom from injurious gases, which made it an exceptionally clean melting machine, the advantages to the men working it were considerable. There was no lifting of heavy crucibles, and tapping was easily done by tilting the furnace. The lining was not easily destroyed, and with small repairs would last from seven to eight weeks. He hoped he had been able to show that the induction furnace was capable of reducing the cost of production of crucible steel.

Tungsten and chrome steel, as well as other steel alloys, could easily be made, and nickel steel had also been successfully turned out. Several furnaces of this type had already been erected in different parts of the world. At Gysinge, Sweden, a furnace of 175 kilowatts had been in successful operation for the past five years, and two others were being constructed at Guldsmedhythan. In Germany two furnaces were being operated and three were being constructed, two of which were 750 kilowatts. In Switzerland a furnace of 450 kilowatts was now being worked, while another of 200 kilowatts was soon to be started in Spain. In England a furnace of 200 kilowatts was now at work and others were in course of construction.

Book News

Wireless Telegraphy for Amateurs and Students

By Thomas M. St. John. Published by the author in New York. Size, 5 x 7½ inches; 171 pages; 155 illustrations. Price $1.

The author has already published a number of interesting electrical books for boys, and now that wireless telegraphy has developed into a plaything for electrically inclined youths, it seems fitting that he should fill out the list with the book before us.

The various pieces of apparatus are not only described and illustrated, but the author also tells how they may be constructed. In doing this, however, the book is sometimes disappointing. We become interested in finding out how something is to be made and then we strike (see the author's book on "So and So"). Perhaps we are expecting too much in one book, however. The book does tell how many of the things may be simply made, and we think it will interest a large number of the abovementioned youths.

Quasi-Public Corporation Accounting and Management

By John F. J. Mulhall. Published by the Corporation Publishing Company, of Boston. Size, 6½ x 9½ inches; 199 pages. Price $5.

The interest which accounting has for the central station manager is indicated by the recent appointment by President Williams, of the National Electric Light Association, of a committee to report on systems adapted to electric light plants. In the book before us we believe that some valuable suggestions may be obtained by the manager who is studying this question.

The properties dealt with are water works, gas works, electric plants, steam heating plants, telephone companies and electric railways. The question of organization is first taken up, and the procedure up to the issuing of stock is described. In the chapter on securities are given forms of common and preferred stock certificates, bonds and mortgages.

In dealing with each class of properties the author has given very complete data as to cards, bills, reports, and the various books needed. As our readers will be interested mainly in material given for electric light plants and railways, we will confine ourselves to these. Under gas works, however, a number of pages are given up to the form of report required by the gas and electric light commissioners of Massachusetts.

The cash book, journal and ledger for an electric light plant are dealt with, the forms with the headings being given. The classification of revenue, operation and maintenance, fixed charges and construction are next discussed, the various items placed under each class being indicated. The various forms of records given include a construction record book, plant equipment book and a real estate book. A station record book is also described, but not illustrated.

Under electric railways, the cash book, journal and ledger are also discussed, together with the classification of revenue, operation and maintenance, fixed charges and construction. The forms given include yearly report of income, construction record book, equipment book for rolling stock, equipment book for the power station, water-power plant construction book, and real estate book. An operating book for the power station is also described.

In the succeeding chapter are taken up the combined inspection and customers' registers. The forms for these are given for one class of properties, but the necessary headings for each class are indicated. The duties of the purchasing agent are discussed, with the forms for department orders, requisitions and invoices.

Under sales department are discussed solicitors, credits, collections, claims, complaints and the display of fixtures for advertising their use. The care of plans of the system, buildings and equipment is briefly discussed, and also the advisability of installing a chemical and testing laboratory, and the making of periodical examinations and audits.

In dealing with depreciation, the author places it for electric light plants from 5 to 10 per cent., and for electric railways from 5 to 8 per cent. In connection with this is given the section of the Massachusetts law compelling gas and electric light companies to include in the tax levy 5 per cent. of the cost of the plant as a depreciation fund.

Several pages are devoted to tables of annuity, compound interest and sinking fund, together with miscellaneous account and instrument forms.

Any manager who is seeking for some information along the lines dealt with will find the book of no little value to him.

Elementary Experimental Magnetism and Electricity

By William Allanach. Published by Longmans, Green & Co., of New York. Cize, 5 x 7½ inches; 265 pages; 143 illustrations. Price, $1.20.

Had the author treated his subject in the usual way of elementary electrical books, we fear he could have found no excuse for adding to the already long list. However, the method of treatment is essentially different, and the book is deserving of consideration on that account.

To illustrate the principles of magnetism and electricity and the attendant phenomena, experiments are described in detail, so that the student or instructor may perform them. Following the demonstration, the student reads the explanation of the results observed. No distinction is made between experiments adapted for lectures or for demonstrations only in the laboratory, nor is it specified when they shall be performed by the student himself or by the instructor, this being rather left to the latter's judgment.

The plan of teaching advocated by the author is that, after the experimental demonstration, the student shall place in writing his observations and the principles involved. This, of course, is a logical part of the plan. If a student merely memorizes the description of the experiment, doubtless he will forget it the next day or so. If he performs the experiment, it will be more firmly fixed in his mind: but with the necessity of afterwards writing down his observations, his whole attention must be given to the phenomena as they occur, so that he may fix them still more firmly in his mind. This plan, if fully carried out, should be a valuable one.

Electrical and Mechanical Progress

A Dust Determinator for Blast-Furnace Gases

THE cleaning of furnace gas is becoming of great importance in the economical manufacture of iron and steel. It not only is necessary to clean furnace gas of practically all the solid matter in order to use the gas successfully in internal combustion engines, but it is found very desirable and productive of economy to clean the gas used in the stoves of a blast furnace, as the dust is deposited on the heating surface and prevents the rapid absorption of heat.

When blast-furnace gas is used for fuel in the cylinder of an engine, a very small amount of dust is prohibitive, as, being naturally gritty, it will unite with the lubricating oil and form a pasty mass which produces an abrasive effect only excelled by oil and emery. As 75 per cent. of the dust is metallic oxide, it will be precipitated as iron or steel when subjected to a temperature of 3000 degrees F., the temperature of combustion.

The impalpable dust, so light that it will be carried along with the current of gases, does not affect the furnace stoves so rapidly, and the gas used for these regenerators need not be as clean as that used in the engine cylinders. When used under boilers for making steam, the freer the gas from solid matter the better. The efficiency of gas-fired boilers depends as much on the side of the tube next to the fire being clean as the side surrounded by the water.

Apparatus for cleaning gas, then, would depend upon the purpose for which the gas is to be used. Cleaners vary in design and operation, and they, too, have to be cleaned when the gas delivered contains more dust than allowable for the particular purpose for which it is to be used.

An apparatus which will separate every atom of dust from the gas passing through and leave it in such shape that the grains or grammes of dust per cubic foot of gas can be determined, is an essential accessory for a steel plant using gas cleaners for furnace gas.

The ordinary method of determining the dust in air or gas is to make a filter of a glass tube filled with absorbent cotton, through which flows the air to be filtered. The gas is measured through a test meter and the cotton is weighed before and after. This method might give accurate results if the cotton always had the same density throughout the tube and were not hydroscopic. The cotton may be packed in so loosely that some of the dust will work through, and unless the former is carefully dried over calcium chloride and weighed several times, a long and tedious process, errors will naturally arise. Experiments have shown that if two cotton-filled tubes are used in tandem, the second will increase in weight, showing that some

FIG. 1.—AN APPARATUS MANUFACTURED BY THE SARGENT STEAM METER COMPANY, OF CHICAGO, FOR DETERMINING THE PERCENTAGE OF DUST IN BLAST FURNACE GASES

of the impalpable dust is not retained by the first tube.

The filtering medium for the apparatus herein described is simply a diaphragm of white filter paper through which the gas percolates,

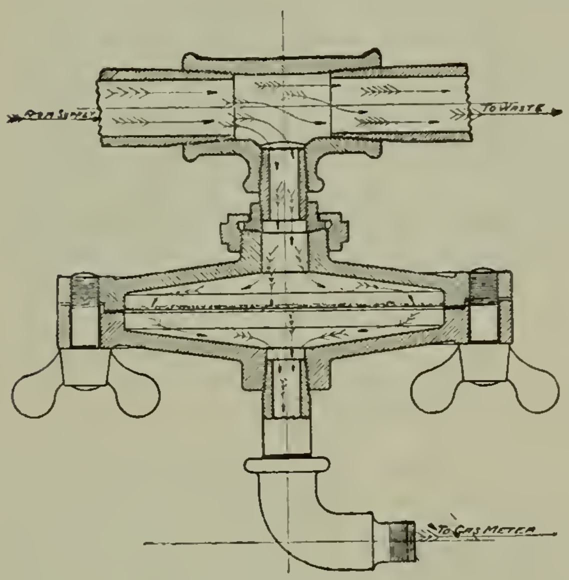

FIG. 2.—FILTER OF THE SARGENT STEAM METER COMPANY'S DUST DETERMINATOR

but on account of the minute interstices of the medium, every atom of dust or dirt remains behind. The side through which the gas enters becomes the colour of the dust, while the other side remains uncoloured. When two filters are used in tandem, the second does not increase in weight, showing that no dust permeates such a filtering medium. The velocity of gas is not rapid through the filters and test meter, which has but a ¼-inch pipe, and if the instrument be erected some distance from the main supply pipe the deposition of dust on the way to the filter will cause an appreciable error.

In the apparatus illustrated herewith, and manufactured by the Sargent Steam Meter Company, of Chicago, a ¾-inch pipe passing across the top of the filter holder, Fig. 1, allows a considerable quantity of gas to pass the opening to the filter at a fair velocity, keeping the dust stirred up. The amount filtered out must be indicative of the total dust in the gas.

By keeping continuous records of the dust in the gas before and after cleaning, the efficiency of the cleaners can be maintained. A check on the operation of the furnace is possible, and the minimum wear of the engine cylinders is insured. A record of the condition of the furnace gas is essential in its commercial use.

Fig. 2 shows the complete self-contained determinator, which consists of a portable case containing an accurate test meter, two filter holders, cross-connected ¾-inch brass piping, so that gas to be tested may flow over the mouth of either filter, and hose connections allowing the gas passing through the filter paper to be accurately measured through the test meter.

When the percentage of moisture in the gas is desired, it is passed through a cooling coil, where most of the moisture is condensed and precipitated in a collecting bottle. From the cooling coil the gas is passed through three or four bottles of calcium chloride, removing effectually any further moisture in the gas before it is metered or its calorific value determined. When the determinations are merely for finding the percentage of dust, the cleaned gas, after leaving the meter, is mingled with the main supply and burned or wasted to the atmosphere. The cleaned, dry gas may be passed through an automatic calorimeter, not shown, by which the B. T. U. are determined, as well as the hydrogen in the gas. A complete record of the dust and calorific value is an indication of the internal furnace conditions, desirable in the economical manufacture of steel.

By using two filter holders continuous determinations can be made. By the proper manipulation of the valves, gas can be passed through either filter while the dust collected in the other, per cubic foot of gas burned, is being ascertained. On account of the moisture in the gas softening up the filter paper, a wire gauze is inserted under the filtering medium to prevent the weight of the dust from tearing it. As the deposited dust and filter paper remain more porous if kept warm and dry, an incandescent lamp or candle is burned under the filter holder in use.

The inlet and outlet pipe for gas passes through the case, which is provided with a door and lock, and may be left running twenty-four hours if desired, though hourly readings may be obtained if the variations of the dust under different conditions are desired. The proportion of gas wasting and going through the meter is adjustable, and can be regulated to suit the conditions and location of the apparatus relative to the flue from which the sample is taken. If the burning or wasting of the gas flowing by the filter mouth is not desirable, it may be piped back into the gas flue in such a way as to maintain a circulation through the shunt.

Metallic molybdenum and a number of its alloys have been produced in Germany by Dr. C. Lehmer, who used an electric furnace of the Héroult type.

Cable Reel Jacks

CABLE REEL JACKS, recently placed on the market by the Colman J. Mullin Company, of Brooklyn, are shown in the annexed illustrations. These jacks have been designed to meet the demand created by the handling of heavy and cumbersome reels of lead-covered cable now so extensixely used for transmission purposes.

A great advantage claimed for these jacks is that they occupy little space in being carried from place

THE "TRIUMPH" TYPE OF CABLE REEL JACK BUILT BY THE COLMAN J. MULLIN COMPANY, OF BROOKLYN

to place. The "Triumph" type of jack occupies a space of 6 by 30 inches, and at the same time is as stable as can be desired. This feature is valuable when the jacks are used to support the reel over a manhole located alongside a car-track or on a busy street corner. A wagon may pass, where it would otherwise be impossible, and, moreover, the operator has more room in which to work.

Another important feature is that the throat of the stand is not threaded, the head being raised by turning a nut bearing on the top of the throat. The screw may, therefore, be readily removed, making the jack easier to carry on a truck.

THE "PERFECTION TYPE OF CABLE REEL JACK BUILT BY THE COLMAN J. MULLIN COMPANY, The head is rigid, and so does not offer an unsteady support for the reel, thus avoiding excessive wear on the head or the stripping of threads on the screw.

In addition to the "Triumph" type of reel stand, the company manufactures other types, one of which, the "Perfection," is illustrated herewith. The company is prepared to manufacture jacks or other devices for the needs of underground cable construction according to specifications furnished by customers.

Self-Contained Belted Alternators

THE Allis-Chalmers Company, of Milwaukee, Wis., have recently developed a line of small 60-cycle, belted alternators, one of which is illustrated herewith. These machines are self-contained, and are built for outputs ranging from 50 KW. at 1200 revolutions per minute to 150 KW. at 900 revolutions per minute, two or three-phase. They can also be furnished for single phase in outputs ranging from 37½ KW. at 1200 revolutions per minute to 110 KW. at 900 revolutions per minute. As shown in the illustration, the bearings are supported in end housings bolted to the stator yoke so that the whole machine is self-contained and requires no base. The stator yoke rests on slide rails, to which it is bolted.

These machines are of the revolving-field type, the armature being stationary. The stator punchings are of selected steel carefully annealed, and are supported in a cast-iron yoke provided with numerous openings to allow free circulation of air.

All armature coils are form wound. As the slots are open, the coils can be readily removed, thus giving a decided advantage over machines having closed slots, in which the coils are difficult to replace in case of accident. The projecting stator yoke and end housings completely protect the ends of the coils where they project beyond the laminated core.

The field poles are built up of steel laminations riveted between end heads and dovetailed and keyed to a spider or hub. The field coils are wound with square wire, which makes a very compact and durable winding. Exciting current is supplied to the field through cast-bronze collector rings mounted on the shaft between the field and the outboard bearing. The bearing housing has three arms, as shown in the illustration, thus leaving the space around the collector rings and brushes easily accessible. Each ring is provided with two brushes. The machine illustrated has the shaft extended to receive a pulley for driving a belted exciter; they can, however, be furnished without the extended shaft. The bearings are of the ring-oiling, self-aligning type, and are of liberal dimensions; both bearings are of the same size.

A 60-CYCLE SELF-CONTAINED BELTED ALTERNATOR, BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS.

The electrical performance of these alternators is unusually good. The fields have sufficient margin for handling inductive loads, the efficiency of the machines is high and the rating conservative.

10,000-KW. Westinghouse Turbine Units for Rapid Transit Work in Brooklyn

STEAM turbine electric generating units of 10,000-KW. capacity are to be installed in the Kent avenue station of the Brooklyn Rapid Transit Company. The order for these is distinctive in that it is the largest ever placed for power generating machinery, and that the units are of the largest size contemplated at the present time. The new equipment will consist of five 10,000-KW. turbo-generator units and a large amount of converting, transforming and controlling apparatus, all built by the Westinghouse interests.

In compactness, the new unit establishes a new standard. Over-all the turbine measures 24½ feet in length, 15 feet in width, and 12¼ feet in height above the floor level. This is equivalent to 3.8 rated B. H. P. per square foot occupied, or 5⅔ B. H. P. maximum; conversely the turbine requires 0.026 square foot per rated B. H. P., or 0.018 square foot per maximum B. H. P. The combined unit measures approximately 48½ feet in length, equivalent to 0.075 square foot per KW. rated, or 0.049 square foot per KW. maximum.

The turbine equipment is designed for a steam pressure of 175 pounds at the throttle, 100 degrees superheat and 28 inches vacuum. Under these operating conditions assumed, the units are capable of sustaining their full rated load continuously with a temperature rise of 35 degrees C., with power factor ranging from 90 to 100 per cent. In the event of loss of vacuum, accidental or otherwise, the turbines will automatically "go to high pressure," carrying their full rated load without the assistance of a condenser. This feature will be obtained through the use of a secondary admission valve of construction similar to the primary valve and operated by the governor in such a manner as to automatically come into operation when the overload upon the machine reaches a certain point. The action of this valve is to raise the pressures in the various stages and thus increase the capacity of the machine.

Speed variation may be adjusted to a nicety by a distant control mechanism attached to the governor and operated from the switchboard. Close regulation may be obtained if desired when running alone, and when running in parallel with other machines the regulation may be changed to 3 per cent. of 4 per cent., if found desirable.

In the construction of the generator the standard rotating field design will be employed with frame entirely enclosed so as to facilitate forced ventilation and incidentally obviate the noise emanating from high-speed turbines. Current may be delivered at 6600 or 11,000 volts, according to the method of connecting the windings.

A good feature of the horizontal type turbine is the excellent disposition which may be made of the condensing apparatus. In spite of the compactness of these large units, the surface condenser will be located, as usual, directly beneath in the power house basement, together with all of the condensing auxiliaries, thus giving a clear engine room floor. This arrangement likewise permits of the most effective means of carrying out the "unit system" in power plant design, which is so important in securing the best arrangement of boiler plant.

Additional Electrical Equipment for the West Jersey & Seashore Railroad

BECAUSE of the increased traffic on the Camden-Atlantic City electric trunk line, it has become necessary to add to the present rolling stock about twenty-one cars. Both the new cars and the generating apparatus necessary to care for the extra load are similar to the present equipment. Each of the cars will be driven by a GE-69 (200-H.P.) double-motor equipment, and will be fitted with the Sprague-General Electric Type M control.

At the Westville power house a fourth 2000-kilowatt, 6600-volt, 25-cycle, three-phase Curtis steam turbo-generator will be installed. Additional boiler capacity, with the necessary condenser and feed pumps, switchboards, etc., and a 75-kilowatt, 125-volt, horizontal Curtis steam turbo-generator for excitation purposes, will also form part of the new equipment. Three extra 700-kilowatt, air-blast transformers will step up the generator voltage to 33,000 volts for transmission.

A 1000-kilowatt rotary converter will be distributed in the sub-stations at South Camden, Glassboro, Newfield, Mizpah, Atlantic City, and one at the Westville power house. The accompanying air-blast transformers for these machines have a capacity of 370 kilowatts each, three being installed with each of these rotaries. The Pennsylvania Railroad has ordered all the additional apparatus from the General Electric Company, which also furnished and installed the initial equipment.

Personal

O. A. Honnold, who has been acting as electrical engineer of the Utah Light & Railway Company, has been appointed chief engineer. Joseph S. Wells has been appointed acting general manager of the company.

In order to meet the demands of increasing business, W. S. Barstow & Co., of New York, and Portland, Ore., have recently enlarged their power plant department, which is in charge of Perry West. Mr. West, graduating from the State College of Kentucky, Lexington, with the degree of M. E., held the position of general equipment engineer with Joseph Williams & Co., of Louisville, Ky. Subsequently he was associated with Pattison Bros., of New York, and was actively engaged in steam turbine work. Recently he has been with the New York Edison Company, associated with George A. Orrok, chief mechanical engineer, resigning to take his present position with Barstow & Co. Associated with him is Carl F. Schreiber, a graduate of Columbia University. Mr. Schreiber is favourably known for his work in the testing department of the Brooklyn Rapid Transit Company, and in the steam department of the New York Central & Hudson River Railroad; he was also one of the engineers of the Electric Traction Commission. Later Mr. Schreiber worked in conjunction with George F. Hanchett, consulting engineer. Another notable addition to the staff is Rulof Klein. Graduating from the Delft Technical University, of Holland, Mr. Klein entered the field of gas engineering. Among other work in this country, Mr. Klein acted as designing and constructing engineer in the gas engine department of the Wellman, Seaver, Morgan Company, of Cleveland, O. He has just returned from Europe, after making a tour of inspection of gas engine power plants in Germany and Belgium. Mr. Klein is a member of the Royal Institute of Dutch Engineers.

Robert McF. Doble, of Colorado Springs, Col., formerly of San Francisco, Cal., has been retained as consulting and supervising engineer by Messrs. Curtis & Hine, general managers of the recently organized Central Colorado Power Company, in the development of their large hydro-electric power projects on the Grand River, Colorado.

S. W. Smith, formerly with the Canadian Westinghouse Company in their Montreal office, has accepted the position of Ontario representative for the Packard Electric Company, of St. Catharines, with headquarters at Toronto. Mr. Smith has many friends in Toronto and throughout Ontario, who will be glad to notice his appointment to this position.

H. J. Lamborn has been appointed superintendent of power and plant in the Yale & Towne works, to succeed F. A. Waldron, who resigned about a year ago. The position is a very responsible one, involving, as it does, the management of all steam and electrical plants, and the supervision (and frequently the designing) of new buildings. The work involved thus requires not only executive ability, but also the training of an engineer and broad technical experience. Mr. Lamborn was born in Philadelphia in 1873, and graduated first from the Philadelphia high school and later from the Towne Scientific School of the University of Pennsylvania in the course of mechanical engineering. For three years he was associated with John C. Trautwine, Jr., in editorial work for the "Civil Engineer's Pocket Book"; then for four years connected with the engineer department of the United States Army on harbor and fortification work near Philadelphia, and then for a year with the Hyatt Roller Bearing Company as mechanical engineer. Since 1902 he has held the position of mechanical and electrical engineer and superintendent of the Magnetic Separating Plants of Witherbee, Sherman & Co., at Mineville, N. Y. (on Lake Champlain).

John E. Zimmermann, formerly secretary of the American Pulley Company, of Philadelphia, is now a partner in the firm of Dodge & Day.

Charles K. Stearns, mechanical and electrical engineer, has removed his

Boston office to the Broad Exchange building, 88 Broad street.

William J. Clark, general manager of the foreign department of the General Electric Company, was appointed by Governor Hughes as a delegate from New York State to the national convention for the extension of the foreign commerce of the United States, which was held at Washington, D. C., beginning Monday, January 14. Mr. Clark has been for many years interested in and studied the conditions of foreign commerce, and his book, "Commercial Cuba," is recognized as an authority on the subject. He has been a delegate to many important commercial conventions, and in 1905 was a member of the United States delegation at the International Railroad Congress at Washington.

E. L. Broome, steam engineer of the New York Central & Hudson River Railroad Company, has resigned to join the forces of the Stone & Webster Engineering Corporation, of Boston, Mass. Mr. Broome will be succeeded by Mr. W. C. Miller, Jr., formerly assistant steam engineer.

Frederick N. Bushnell severed his connection on February 1 with the Rhode Island Suburban Railway Company, of Providence, R. I., as chief engineer, to enter the employ of Stone & Webster, of Boston. Mr. Bushnell received his early mechanical training at the Providence Steam Engine Company, filling various positions in the shop and drawing room until he became designing engineer in 1889. He then spent a year in Chester, Pa., returning to the Providence Engineering Works as general superintendent in 1891. In 1893 he left the company to take up the building of the improved Greene engine at the Fuller Iron Works, in Providence, but owing to the financial troubles which occurred in the spring of that year, this project had to be abandoned. Mr. Bushnell then became chief engineer for the Narragansett Electric Lighting Company, which position he has held since that time. In 1901 he also became chief mechanical engineer for the United Traction & Electric Company, which controlled all the electric roads in Providence, Pawtucket and the surrounding towns, and in 1902, when these street railway properties were purchased by the United Gas Improvement Company, of Philadelphia, Mr. Bushnell was appointed chief engineer of the system.

H. A. Currie has been appointed assistant electrical engineer of the New York Central & Hudson River Railroad Company, to succeed J. D. Keiley, recently appointed electrical engineer of the company. Mr. Currie has been associated with the electrical department of the New York Central Railroad since 1903, when the plans of the company for electrification were first undertaken. He has had a long electric railway experience, having been connected with the Brooklyn Rapid Transit Company for the nine years between 1894 and 1903. In Brooklyn he was engaged in power station work for six years, and later he was appointed as assistant to Mr. Keiley, who had charge of the engineering work in connection with the rolling stock of the surface and elevated divisions of the company.

Henry Docker Jackson announces the removal of his office from 4 State street to Room 626 Broad Exchange building, 88 Broad street, Boston, Mass., where he will carry on his business of consulting electrical engineer. He will make a specialty of reports on electrolysis, power distribution for mills, railways and lighting companies, power-plant economy and on proposed or existing plants for financial houses.

Trade News

The Babcock & Wilcox Company has bought from the Stirling Consolidated Boiler Company, as of Dec. 31, 1906, its American property and interests, including all accounts and bills receivable, and has assumed its obligations and will execute its orders and contracts for boilers and appurtenances for installation and use in the United States. The plants thus purchased will be operated in the future by the Babcock & Wilcox Company under the name and style of "The Babcock & Wilcox Company (Stirling Department)," and will be operated under the direct charge and management of the same gentlemen who have operated the Stirling Consolidated Boiler Company. The gentlemen who have been connected with the Stirling Consolidated Boiler Company in its sales department will be associated with the Babcock & Wilcox Company in similar capacities. The Babcock & Wilcox Company (Stirling Department) will manufacture the Stirling, Aultman & Taylor and Cahall water-tube boilers and appurtenances heretofore manufactured by the Stirling Consolidated Boiler Company.

Announcement is made by the DuBois Iron Works, of DuBois, Pa., that they have taken over the entire business of the Lazier Engine Manufacturing Company, of Buffalo, N. Y. The DuBois Iron Works have been manufacturing gas and gasoline engines for years under the patents and designs of Arthur A. Lazier former vice-president and general manager of the Lazier Engine Manufacturing Company, who has sold out his entire interests and retires from the business management and company. While in general the future engine may have the same appearance, numerous improvements and changes will be made. The DuBois Iron Works have not only improved the engines in construction and design, but have made it possible to operate them on natural, illuminating and coke oven gas, gasoline, alcohol, distillate, crude oil and kerosene in sizes ranging from 5 H. P. to 300 H. P. Peter Eyermann, one of the foremost gas engine authorities, designers and engineers from Germany, is chief of the engineering department, and under his designs and supervision the new and improved "DuBois" will be produced. The company will continue the manufacture of their celebrated "Simplex" steam pump, which has had a large use in the mining industry. The officers of the company are: John E. DuBois, president; W. C. Pentz, vice-president; E. A. Badger, secretary and treasurer, with I. N. Hamilton as general manager. The sales and advertising department will be in the hands of C. E. Stuart. The head office and entire management will be located at DuBois, Pa. At Buffalo, which formerly was the Lazier Engine Manufacturing Company's headquarters, a branch office will be retained, together with branches in the principal cities throughout the country.

W. S. Barstow & Co., of New York, and Portland, Ore., have contracted to do all the electrical work for an 800-000-barrel cement plant, to be located on the outskirts of Montreal, Canada, for the Fordwick Company. The works will have about 2500 H. P. in electric motors, and will take current from the Shawinigan power plant, eighty miles from Montreal. The property of the Fordwick Company is about two miles in length by 600 feet in width, along the St. Lawrence River. Provision will be made for storing 40,000 tons of coal adjacent to the works. Barstow & Co. have been retained also by the Danbury & Bethel Electric Light & Gas Company, who will remodel their present plant completely and install 400 kilowatt additional capacity. This will include the complete additional steam plant building, coal storage and electrical apparatus.

Dodge & Day, engineers, of Philadelphia, are building the new shops for the Jones & Lamson Machine Company, at Springfield, Vt. The work is being pushed as rapidly as possible, and the order for steel has already been placed. The new building for the Bridgeport Brass Company, which is being engineered and constructed by Dodge & Day, is well under way, the steel having been ordered and the foundation work nearly completed.

The Prometheus Electric Company, of New York, have recently contracted to supply a large concern in Mexico with their heating apparatus. This is probably the largest export order ever put through for electrical heating apparatus. One of the many specialties of the company has been their well-known plate warmers. During 1906 they equipped a large number of private residences and hotels. Among the new and useful designs produced this year may be noted a water kettle. They are also showing an attractive line of chafing dishes, percolators, ovens, flat-irons, and other heating devices.

The Buckeye Electric Company, of Cleveland, Ohio, are sending out a series of "lamp talks," of which two, —"About Regular Lamps," and "Tantalum Lamps,"—have been issued. The "talks" are just what their name implies,—information regarding the lamps given in a chatty, conversational style.

The Standard Underground Cable Company, of Pittsburg, announce that they have recently opened branch offices at Atlanta, Ga.; Los Angeles, Cal., and Seattle, Wash.

M. W. Dunton & Co., of Providence, R. I., are sending out an attractive calendar for 1907. The calender shows the products manufactured by the company.

August Mietz, of New York, announces that the commission appointed by the French Government to report on petroleum engines for the French Navy has completed the tests of various engines, and has recommended the Mietz & Weiss engine. The 22 H. P. Mietz & Weiss engine used in the tests has been purchased by the commission.

New Catalogues

A folder recently issued by the Wilkinson Steam Turbine Company of Providence, R. I., deals with the steam turbine built by that company. Sectional views are shown of the assembled turbine, and the details are also illustrated and fully described. Besides machines for driving electric generators, the company also builds a type for marine use, for driving centrifugal pumps, blowers, and circular saws.

Automatic telephone pay stations manufactured by the Gray Telephone Pay Station Company, of Hartford, Conn., are illustrated and described in an attractive catalogue recently issued. A wide variety of apparatus is shown, including cabinet pay stations, registers for measured service on private or party lines, and street corner stations. A muffler, for keeping extraneous noises from affecting the transmitter, is also described and illustrated.

The Hawthorne works of the Western Electric Company, of Chicago, are fully illustrated and described in an attractive pamphlet recently issued. The illustrations show the exterior of the buildings, different parts of the shops, and some of the installations of generators made by the company.

"The Insulator Book," a pamphlet issued by the Locke Insulator Manufacturing Company, of Victor, N. Y., shows a wide variety of insulators manufactured by the company. Several pages are devoted to notes of testing, the various methods being briefly described with the aid of diagrams.

A circular recently sent out by the Coffin Valve Company, of Boston, Mass., contains an illustration of a 108-inch circular sluice gate built by the company. This is one of thirteen furnished to the Niagara Falls Hydraulic Power & Manufacturing Company.

A very valuable series of five maps, sent out by the Ontario Power Company, show the various districts served by Niagara power. Map No. 1 shows the district of the Ontario Power Company; No. 2, Eastern Ontario and Western New York; No. 3, the Welland Canal; No. 4, Niagara Falls and vicinity; No. 5, Buffalo, Depew, and West Seneca.

Rotary converters built by the Allis-Chalmers Company, of Milwaukee, Wis., are dealt with in a recent pamphlet. Other literature sent out recently are bulletins illustrating and describing direct-connected Reynolds-Corliss engines, belted Corliss engines, and polyphase induction motors.

A catalogue recently sent out by the Atlas Engine Works, of Indianapolis, is devoted to a variety of engines and boilers built by the company. The engines illustrated are the single-valve throttling, the twin-coupled throttling, the four-valve automatic, and the side-crank, splash-oiling types. The boilers are of the horizontal tubular, vertical tubular, locomotive and water-tube types.

Electric cooking and heating apparatus are illustrated and described in a catalogue recently issued by the Prometheus Electric Company, of New York. The list includes food and water heaters, water kettles, water urns, tea kettles, coffee pots, coffee percolators, chafing dishes, griddles and toasters, waffle irons, cone cake bakers, ovens, kitchen ranges, plate warmers, air heaters, radiators, curling iron heaters, flat irons, glue heaters, and instrument sterilizers. The company is also prepared to furnish estimates on special heating equipments of every kind.

A card sent out recently by the National Carbon Company, of Cleveland, Ohio, emphasizes the uniformity of the "Columbia" carbons manufactured by the company. The reader is told to measure a carbon with a micrometer and find that the diameter from end to end varies only in thousandths of an inch.

A few suggestions regarding the "condulets" manufactured by the Crouse-Hinds Company, of Syracuse, N. Y., are given in a pamphlet recently issued. In the 52 pages are given 60 illustrations of how the "condulets" may be used. According to a statement on the cover, however, there are a thousand other ways to use them.

The short life of tantalum lamps on alternating-current circuits is a generally accepted fact in this country, yet in the discussion of a recent paper by James Swinburne, on "Indoor Illuminants," before the Association of Engineers-in-Charge, of London, it was brought out that tantalum lamps were running quite comfortably (600 hours and still going) on the County of London Company's frequency, which is 50 cycles.

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Editorials

Leading Articles

The Potomac Power Plant

THE steam turbine plant of the Potomac Electric Power Co., of Washington, D. C., described elsewhere in this issue, presents a variation from the original design of turbine plants having the boiler-room at right angles to the generator-room, in that there are two firing aisles for four rows of boilers, instead of three firing aisles. This alteration of the layout results in considerable saving of space, the plant as built occupying 29,520 sq. ft. while had three firing aisles been used 2700 sq. ft. additional space would have been required. In cities where land is costly this reduction of area, which does not impair the efficiency of the plant, results in a considerable reduction in the first cost, to say nothing of the saving due to the lessened area of the superstructure and foundations, which in themselves are no small items.

The use of concrete blocks avoids the deadly monotony that seems almost inseparable from the use of concrete molded in place. At the same time a strong structure is secured without the difficult form work required for reinforced concrete. The danger of high temperatures and the hair cracks, which so often mar the monolithic concrete building, are avoided.

The shoe box and stove pipe effect so common in power-house structures is absent in the present case, owing to the means employed to accentuate the separate portions of the building, by their differing heights. The use of skylights and their attendant danger from drippage are avoided; at the same time the side light for the turbine-room is not filtered through several partitions of varying degrees of density. The modest coal hoppers in the track at the rear of the building are a grateful relief from the unduly prominent coal and ash plants so frequently seen and which often give the impression that the main structure is but an annex to this portion of its auxiliary equipment.

The auxiliary machinery, it will be noted, is all on one floor, and the pumps are not stowed away in a dark alley under the boiler floor. The omission of the usual partition at this point brings all the steam-operated machinery into plain sight in the same room and reduces the labor of supervision.

Another of the novel features of this plant is the use of reinforced concrete ash hoppers below the boilers in place of the usual steel-plate structure lined with concrete or fire-brick. These concrete hoppers are fully described and illustrated in a separate article in this issue.

A Vital Electric Traction Problem

The New York Central wreck at Woodlawn has concentrated the attention of experts upon a problem of vital interest to electric railway men. The discussion of the subject in the press promises to differentiate clearly the track performance of electric and steam locomotives, and to bring out many facts of value to those systems which are using, or permitting the use of, electric locomotives on roadbeds suited only to light traffic. It also has a direct bearing on those roads which have adopted high-speed schedules.

The article which appears on another page is not intended to discuss the one-spike theory or the distribution of wheel impact against the rails, but it does point out the fact that there are important lateral forces in the electric machine which are not present to the same degree in the steam locomotive, and that these forces must be reckoned with. In the article these forces and the factors of safety were computed for 4½ inches superelevation. It seems hardly necessary to emphasize the fact that these values would vary with the degree of curvature and the superelevation, together with the speed, and the type of locomotive, which, in this case, was the joint product of the General Electric Company and the American Locomotive Works.

In the analysis it will be noted that at the speed of 60 miles per hour, which is slightly above the schedule, the factor of safety was from 5 to 6 per spike, or double these figures, if two spikes are to be considered. Under these circumstances the occurrence of this accident is inexplicable with the present track construction and the New York Central type of locomotive.

The South Norwalk Municipal Electric Plant.

In another portion of this issue will be found an interesting account of a successful municipal generating plant. This success being, in part, due to the disinterested services of a public-spirited citizen and to the application of sound accounting principles and business common sense to the work. The employees of the plant do not seem to depend for their job upon some ward boss, whose influence is sufficient to override all other qualifications; and as a result of which the outlay for repairs is reasonable for a plant of this size. The data in regard to the cost of generating current indicate that due care is taken to maintain the plant in an efficient condition. The report and balance sheet appear to show a healthy condition and are particularly noteworthy on account of the presence therein of several items which are usually conspicuous by their absence in the reports of such enterprises.

The average cost of generation and fixed charges is low for a plant having a load factor of 17.6 per cent.; at the same time this load factor is higher than that of some municipal plants claiming to produce electricity at lower unit rates. The average income per k. w. h. is apparently reduced a trifle below the normal on account of the low rates charged against the city lighting work. The fuel costs shown by the Diesel engine are low and compare favorably with the results gained by the use of much larger steam-driven units on cheap coal. The cost of coal per k. w. h. is very high, which is probably due to the high cost of coal delivered at the plant, and to the use of the steam units to tide over peaks. This method of operation is not conducive to the best results as regards coal economy, since a large amount of fuel is consumed under banked boilers and in the process of starting up and shutting down the steam plant. Owing to this mode of management, the costs of fuel for the Diesel engine and for the steam plant are not comparable with each other.

This plant is located in a town whose size, while ample to afford a good line of business to a single plant, would not justify the establishment of a competing plant by private capital. This fact is plainly evidenced by the absorption of the commercial business by the progressive management of its municipal rival. When the agitation for a municipal plant started, the privately owned central station adopted the usual tactics used by the public-service corporations of that day and which, to a regrettable extent, prevail at present, which simply added oil to the flames. It is extremely probable that if they had adopted progressive methods they would have been able to make some small concessions and have retained their monopoly of the business.

One of the conspicuous features that stands out in the history of the South Norwalk plant is the devotion of Mr. Winchester, who has thoroughly identified himself with the enterprise and, in effect, supplied the spur of one-man control that makes for the efficiency of all business interprises. Such self-abnegation is not only rare, but in public affairs the man combining the essential qualities of business and engineering management and a willingness to devote himself to an uncertain public service are not often found in the one person, and the following remarks of the Hon. Peter S. Grosscup in a recent issue of the *American Magazine* are pertinent to the case in hand; and while the reference of this able student of economic affairs is to government control, he has stated the question so broadly that it applies to municipal ownership and justifies the present long quotation:

"One controlling economic reason for opposing public ownership is that every individual in society prospers just in proportion as industry gets the best there is in human capability; on the other hand, government control and direction never gets, and in the nature of things never can get, all there is, or the best there is, in human capability.

"Now the government may compete with private enterprise in getting capable men, but it has not thus far shown anything of the capacity of a private enterprise to assign the right man always to the right place. The agency which in private enterprise succeeds so generally in eventually landing in the right place the right man is not simply good intention, nor mere intelligence, but the intelligence and intention which constantly study the enterprise in hand—which make it the one affair in life, constantly thought of and planned for; an intelligence and intention, too, which are themselves as nearly as possible permanent. That kind of seeking out and watchfulness few government departments possess. The men in charge of government departments may be intelligent and well intentioned, but they are in to-day and out to-morrow. The thing under them is not their child. They never, as a matter of fact, get their hands and their mind fully into the work.

"Nor will civil service change this. Civil service examinations may secure capable men, but no civil service examination can assign the right man to the right place, can pick out of the thousand capable men just the kind of capability that is fitted to this place and just the kind that is fitted to that. Indeed, between government control and private control, the difference in that respect is almost the exact difference between what we call true *organization* and what is the merest *aggregation;* for in private enterprise each man has come by a process of attrition to the place he is best fitted to fill, while in government employment each man is dropped into his place, irrespective of special fitness, and under civil service is riveted there."

In the past year the ELECTRICAL AGE has published several articles dealing with the benefits that follow the adoption of broad-gage methods in handling the relations between the public and public-service corporations in preference to the policy of squeezing the lemon dry at once. The policy of building up a prosperous future depends on the conduct of the business now, and the fancied wrongs of a few are liable to outweigh all considerations of good and efficient service. A penny close to the eye can obscure the sun. Necessarily it requires tact to handle an unreasonable patron, ignorant of the many difficulties overcome in furnishing him with an uninterrupted supply. But it will be found possible in most all cases to smooth out such difficulties by going over the matter fully with him and giving him a fair insight into the company's side of the case, and the difficulties met. The man for this post must be one who can keep his temper thoroughly in hand, and the results to be gained are well worth the time spent in such work, unpleasant though it may be. A large company can well afford to detail a man especially to this work, but in a small organization such duties must be combined with others, and it is of the highest importance that the right man is found for the place.

Central Station Underground Cable Record System

In this issue we describe a system for keeping track of underground cables used by the United Electric Light and Power Company of New York.

In the days when overhead construction was permitted, it was a comparatively easy matter for a man to trace out the different transmission lines, as they were in plain sight and not numerous. Where the overhead lines have been replaced by underground cables and gathered into ducts, the proposition is different. It then becomes absolutely necessary to identify every cable at its terminals, and to know its service connections.

The New Plant of the Potomac Electric Power Co. Washington, D. C.

THE Bennings generating plant of the Potomac Electric Power Co., of Washington, D. C., which was recently completed, presents some interesting innovations in power-plant construction. This plant supplies current for light and power purposes, as well as current for a large part of the local street railways, and for the Washington, Baltimore & Annapolis Ry. The plant is located on the Bennings Road, near a branch of the Anacosta River, from which the circulating water for the condensers is drawn.

In the arrangement of the plant the boiler-room is placed at right angles to the generator-room and the switchboard and offices are located in a low annex on the opposite side to the boilers. The structure occupies a ground area 164 ft. x 180 ft., or 29,520 sq. ft. The boiler-room is 120 ft. x 164 ft., the turbine room, 45 ft. x 164 ft., and the switch-room and office annex is 15 ft. x 164 ft. The plant is designed for a normal generating capacity of 19,000 kilowatts, making the ground area per kilowatt 1.55 sq. ft. About 800 tons of structural steel were required for the building. The plant is located on alluvial soil, which required the use of piles; the turbine foundations, however, were carried down to a firmer soil. Raymond concrete piles were used, being driven to a depth varying from 30 to 40 ft. The condensing water conduits were incorporated in the lower portions of the turbine foundations, and to guard against unequal settlement occurring between the different units, the concrete mass was reinforced with old rails.

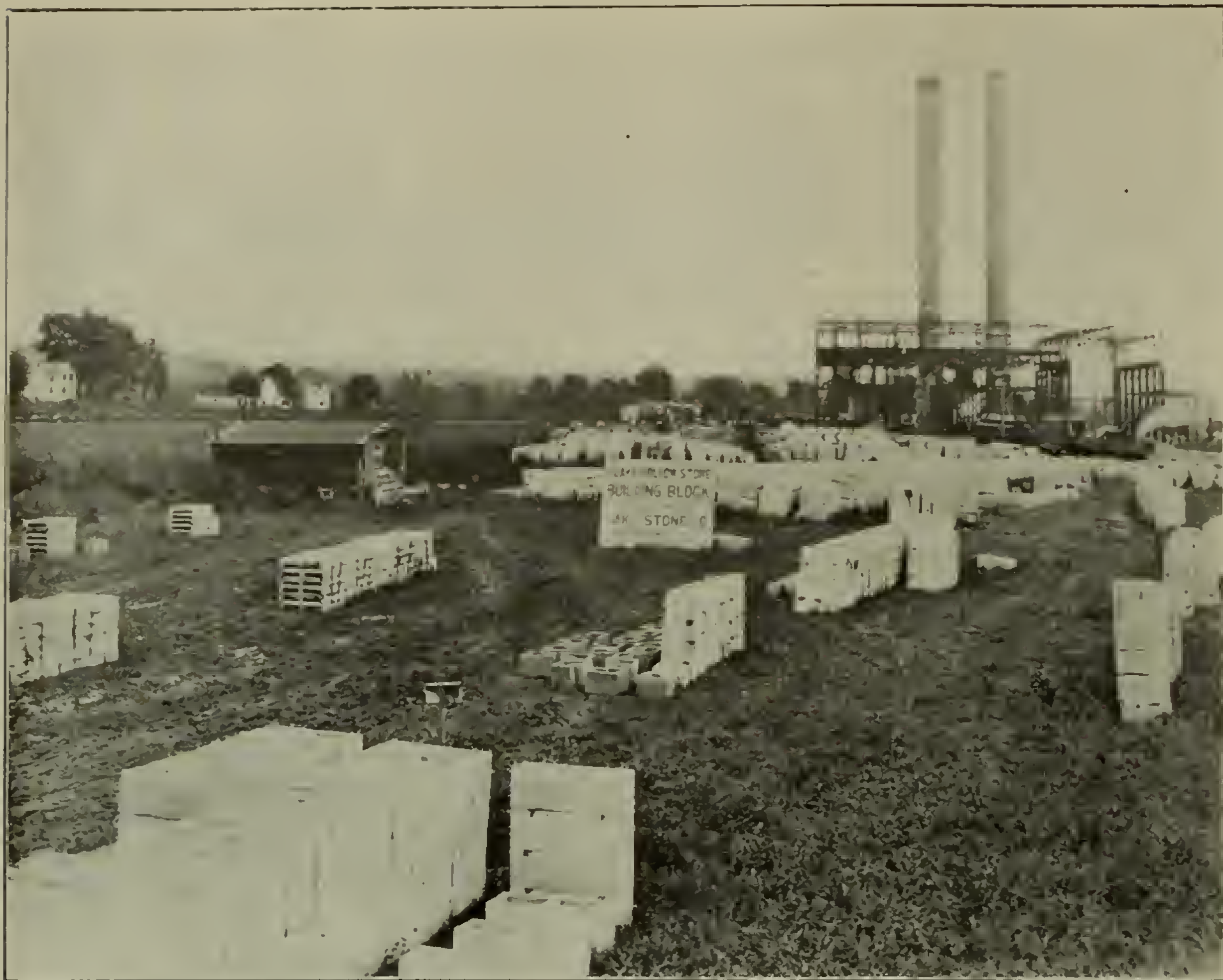
The superstructure was built of hollow concrete blocks, made by the Lake Stone Co., of Washington, D. C., and with the exception of a few interior partitions the walls are self-supporting. The blocks used were of uniform size, 3 ft. x 1 ft. x 1 ft., with the exception of special reinforced blocks required for the window and door lintels and sills. This is the first extensive use of concrete blocks in a power-plant structure.

Architecturally, the plant is designed as three connected structures, the points of separation being accentuated by the difference in height of each portion. The windows are set in panels, and the walls are finished by a neat corbelled cornice. The chimneys are also of concrete, in harmony with the building. The switch-room and office portion of the building is a comparatively low structure, and above its roof large windows are placed in the walls of the turbine-room, thus insuring a plentiful supply of light without the use of skylights. The boiler-room is also lower than the turbine-room and this portion of the plant was laid out in a manner to localize the three chimneys on the center line between the two center rows of boilers. The boiler-room basement has a height of 14 ft., the floor being flush with that of the main generating-room; a portion of this basement is given up to the exciter units and pumps. This part of the basement is open to the turbine-room and a partition separates it from the portion of the basement allotted to the ash-handling plant. A part of this basement is also devoted to a small repair shop, the usual store-rooms, locker and toilet facilities.

Coal is delivered on a siding, parallel with the building, and is dumped from the cars into track hoppers located opposite the end of the firing aisles. From these hoppers the coal passes to crushers and thence to elevators, which raise it to belt conveyors running over the bunkers. The conveyors serving each bunker have a capacity of 40 tons per hour. Each bunker has a storage capacity of 650 tons and consists of a number of inverted pyramidal hoppers, constructed of steel plates reinforced with angles. From the bottom of these hoppers the coal is delivered through cast-iron circular chutes, provided with gravity cut-off gates, to the stoker aprons.

BOILER-ROOM—SIXTEEN BABCOCK-WILCOX BOILERS. 175 LBS. PRESSURE, 150° F. SUPERHEAT

From the stokers the ashes drop into reinforced concrete ash hoppers suspended from the boiler-room floor, from which they are drawn off into side-tip ash cars and conveyed to a hopper which delivers them to the same bucket elevator that serves for handling coal. The elevator raises the ashes to a storage bin located between the two bunkers and in line with the chimneys, from which the ashes can be delivered either to cars or teams, as desired. The reinforced concrete ash hoppers are more fully described in a separate article in this issue.



THE STATION AT BENNINGS IN COURSE OF ERECTION

Building blocks of standard size, 36 inches by 12 by 12 inches; 100,000 cu. ft. of blocks used.

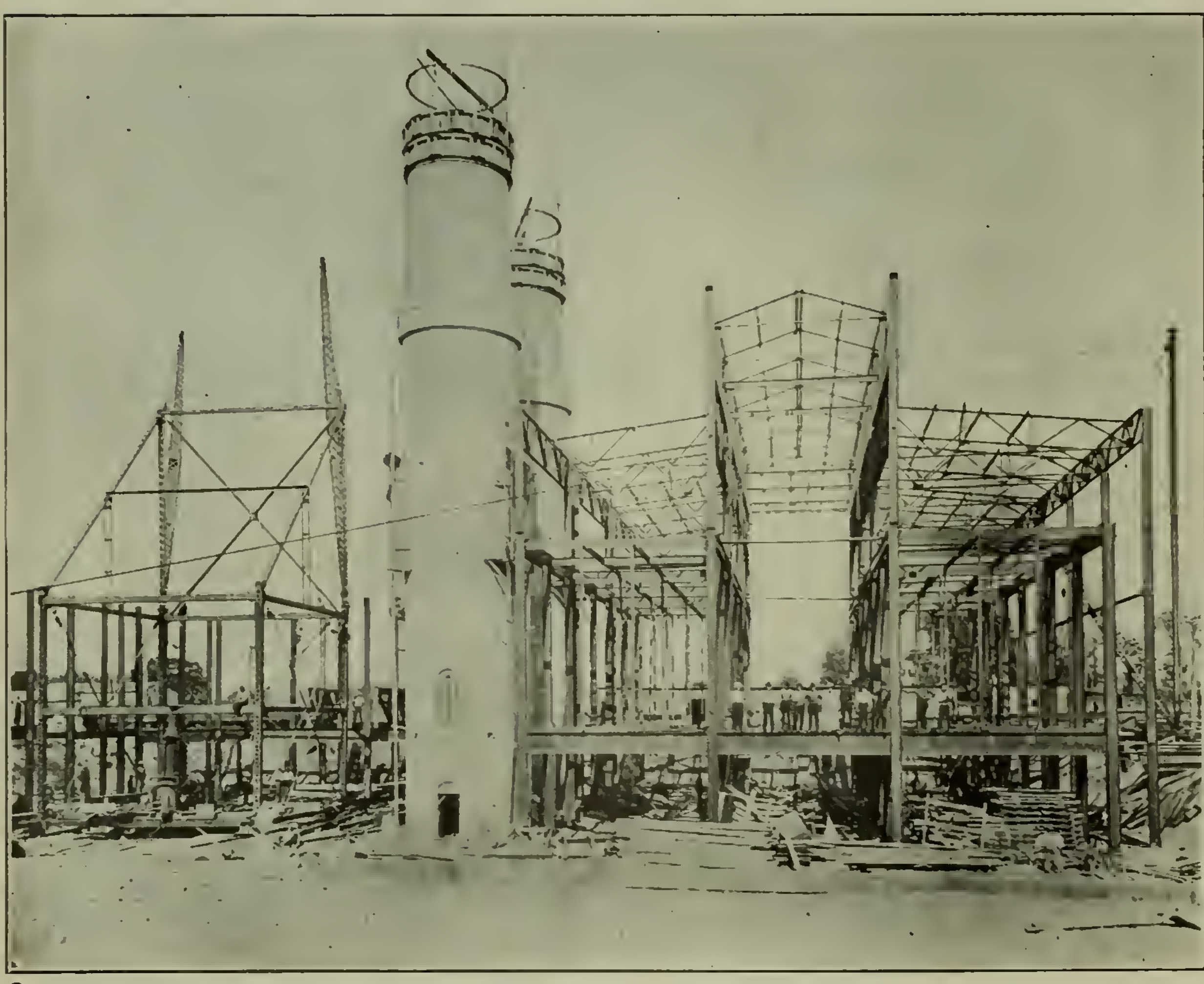
The boiler-room is designed for twenty-four boilers, arranged in four rows facing two firing aisles, each row containing three batteries of two boilers each. The present installation consists of 16 Babcock and Wilcox boilers designed to supply steam at 175 lbs. pressure with a superheat of 150° F. Each boiler has 6040 sq. ft. of heating surface and 1180 sq. ft. of superheating surface of the usual B. & W. "U" type. The Roney stokers used have a grate area of 111.8 sq. ft. per boiler and are driven in pairs by a small Westinghouse engine.

The smoke-flue connections are made on top of the boilers between the drums. The smoke flue connects with a breeching on the center line of the battery passing over the firing aisle and receives the waste gases from the opposite battery a short distance from its junction with the chimney. A damper is provided in each boiler uptake, and an automatically controlled damper is located in each of the four flues at the chimney. The three chimneys were built by the Weber Steel-Concrete Chimney Co. Each chimney receives the gases from eight boilers, the third chimney being for the future installation. The chimney shafts are 12 ft. internal diameter and have a height of 200 ft. from the floor of the basement, and 183 ft. above the grates. While these chimneys are not of unusual height or size, a number of them having been constructed throughout the Middle and Western States, they have not come into extensive use on the Atlantic coast.

These chimneys rest on and are tied to a concrete substructure by the vertical steel reinforced rods of the shaft. The shaft is also reinforced by horizonal rings at suitable intervals. The bore of the chimney is of uniform diameter throughout. The lower portion is built with an inner and outer shell separated by an air space; this leaves the inner portion free to respond to temperature changes. The outer shell supports the upper single shell portion of the chimney, an offset being formed over the top of the lining in a manner which prevents soot from dropping into the air space. Both shells are of uniform thickness, except at the offset, and the outer portion protects the inner from the weather and wind stresses.

The boilers are fed by two horizontal 16 x 14¼ x 16 in. duplex Epping-Carpenter pumps, delivering into a 6-in. ring header, from which risers lead to each boiler. These pumps draw from two Warren Webster open feed-water heaters located on the boiler-room floor in the space between the chimneys, each having a capacity of 200,000 lbs. of water per hour heated from 80° to 205° F. Two make-up tanks with a capacity of 25,000 lbs. of water each are installed in the boiler-room, from which water is drawn to cover the losses due to waste and leakage.

The steam piping is of mild steel with Van Stone loose flanges, and semi-steel fittings, the largest size of pipe used being 15 ins. in diameter. A header in back of the boilers receives the steam and is connected



THE CONSTRUCTION OF THE STEEL-CONCRETE CHIMNEY

NEW CENTRAL GENERATING STATION OF POTOMAC ELECTRIC POWER COMPANY AT BENNINGS, D. C.

across the firing aisle with the header serving the opposite boilers, forming a large letter "U." The two "U's" are cross-connected. The turbines are connected to the header, 10-in. pipes going to the 2000 kilowatt units, and 12-in. pipes to the 5000 kilowatt units. Steam separators are not used, but the system is drained, the drip being piped to the feed-water heaters. The auxiliaries take steam from a 6-in. header in the basement which is drained by two ¾-in. Squires steam traps. These pipes are covered with 85 per cent. magnesia.

The turbines are of the Curtis vertical type with base condenser, the two 2000 kilowatt units being four stage and the 5000 kilowatt units being five stage. There is room for an additional 5000 kilowatt unit, only two machines of this capacity being installed at present. The turbines operate at 750 r. p. m. The condenser for the 5000 kilowatt units has 20,000 sq. ft. of cooling surface; the circulating water is supplied by a 24-in. steam-driven centrifugal pump. The 2000-kilowatt condenser has 8000 sq. ft. of surface, and cooling water is furnished by a 16-in. centrifugal pump. The dry vacuum pumps are of the singe-stage type built by H. R. Worthington. Motor driven hot-well pumps are used. Each unit is supplied with a separate atmospheric exhaust connection leading in a tunnel under the turbine-room floor to the boiler-house where a riser passes to the roof. Blake atmospheric relief valves are placed in these pipes.

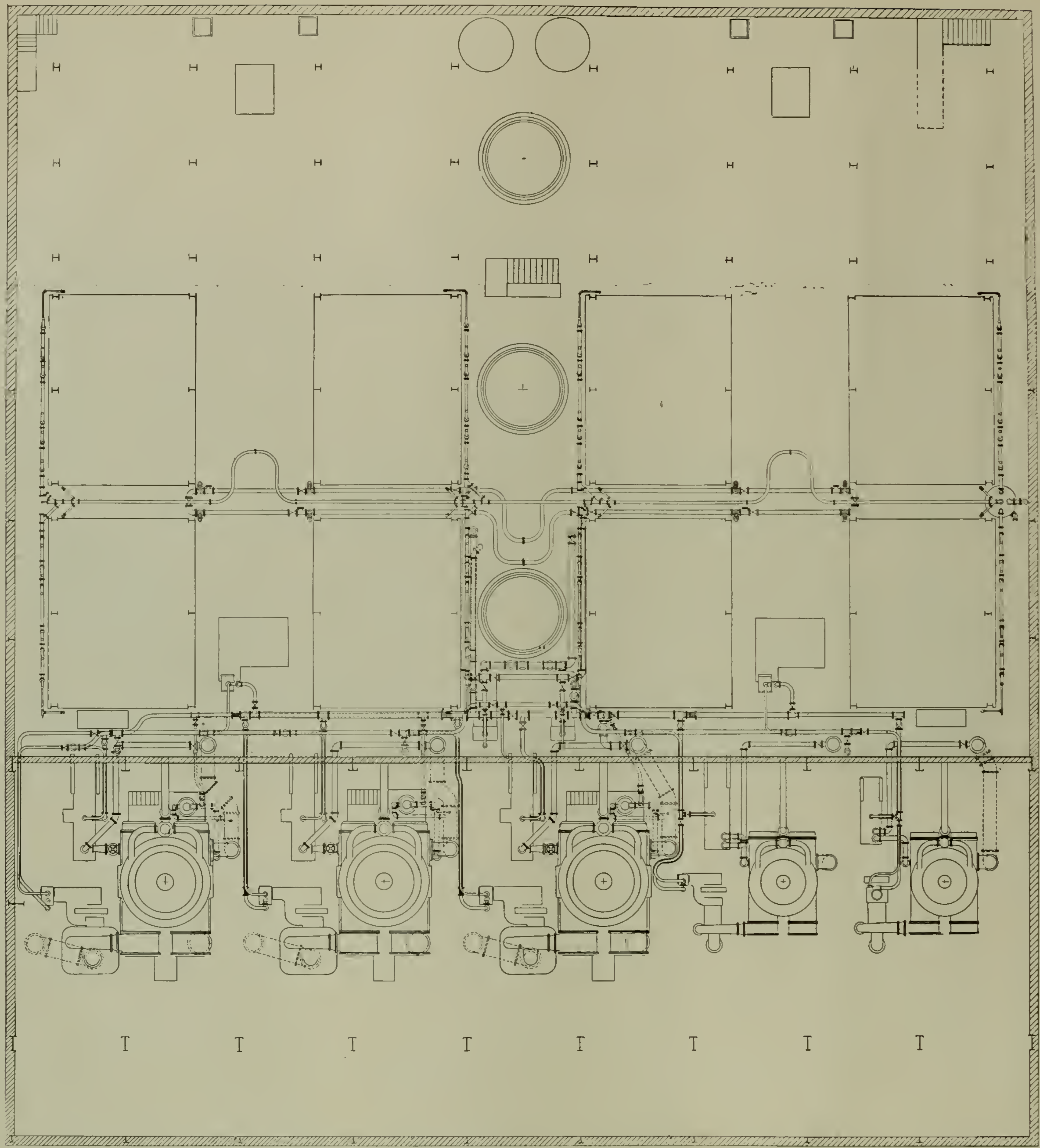
There are two 100 kilowatt 125-volt exciters driven by Harrisburg engines, which also supply such direct current as is required for house purposes. Oil is used in the turbine step bearings, the pressure being maintained by three pumps and an accumulator.

The alternators are superimposed on the turbines and are four pole, 25-cycle machines, designed for 6600 volts. From them the leads pass to the oil switches in the annex; these switches are of the well-known General Electric "H" type.

The designing of the generating plant was done by the J. G. White Co., of New York, and the work was carried out under the direct supervision of L. E. Sinclair, general superintendent of the Potomac Electric Power Co.

In addition to the generating plant, there have been erected four new substations to take care of the increasing load. Substations No. 10, No. 11 and No. 12 were located at stragetic points for extending the service, while new No. 2 is practically an addition to an existing station, and for this reason the amount of space allotted to future units is based upon the united capacity of both installations. Each of these substations was designed to suit local conditions peculiar to itself.

The new substation is a brick structure with steel frame and concrete floor and roof, one-story high. The present installation comprises two 1100-kilowatt three-phase transformers and two 1000-kilowatt rotaries. The transformers are provided with dial switches connected to taps brought out from different points on the transformer secondary winding. This expedient permits the direct-current voltage to be varied. A number of remote control oil switches are installed at this substation to control the incoming and outgoing current, as this plant is used to distribute current to



GENERAL PLAN OF POTOMAC POWER PLANT

Showing the compact grouping of the condensing auxiliaries due to the use of base condensers, and the arrangement of the suction pipes of circulating pump to permit access to the foot valves. The piping runs are short and direct and ample provisions are made for their expansion.

some of the smaller substations. A storage battery having 276 cells can be connected to the three-wire system or the railway circuits. When in lighting service it is cut in two and an end-cell switch having 20 cells connected to it is used to vary the voltage, while for the railway service the end-cell switch is used to vary the amount of load carried by the battery. The battery is charged from the railway circuit. This substation was designed for an ultimate capacity of 6000 kilowatts.

Substation No. 10 was designed for 5000-kilowatt capacity to serve the Edison three-wire system. The present installation comprises two 500-kilowatt motor-generators and a 75-kilowatt balancing set. There is space reserved for the future installation of three 1000-kilowatt rotary converters, and provision is made for the air ducts required for cooling the transformers. The use of motor-generators in a substation, while common abroad, is not so in this country. These machines are provided with induction motors which are started through compensators. The use of motor-generators makes it comparatively easy to start up after a total interruption on the three-wire system, as these machines

ONE OF THE 5000 K. W. TURBO-ALTERNATOR UNITS BUILT BY THE GENERAL ELECTRIC COMPANY

can be got in operation and brought up to voltage and their current utilized to bring the rotaries in. The compensator permits the starting of these machines without causing a sudden surge on the high-tension lines.

A storage-battery room is provided on the second floor of this substation, permitting the installation of 250 cells. This battery will be controlled in the same manner as that in substation No. 2.

Substation No. 11 is in an old office building, remodeled to suit the purpose. Owing to the small space available, the blowers for the transformers were placed in the basement. This station was designed to handle a railway load and is equipped with two 500-kilowatt six-phase rotaries and two 500-kilowatt three-phase air-blast transformers. These transformers are equipped with dial switches similar to those used in substation No. 2.

Substation No. 12 is located in a portion of an old engine-driven power station, space being obtained by the removal of a part of the disused steam plant and generators. The remaining steam equipment is being held in reserve and it is intended to maintain an operating force at this point able to handle the steam machinery in an emergency. The apparatus installed here is designed to carry the load formerly handled by the steam-driven units, and consists of a 500-kilowatt frequency changer and three 500-kilowatt rotary converters. The latter carry a street railway load, while the frequency changer transforms the 6600-volt 25-cycle current to 2400-volt 60-cycle current.

In the building of the main power station over 100,000 cubic feet of Lake concrete blocks were used. The use of cast concrete blocks in this building marks the advent of a new material into the field of power plant construction. A material that lends itsef so readily to the art of the architect and at the same time reduces the cost of the building is certain to find a wide use in this field. The standard size of the block is 1 ft. x 1 ft. x 3 ft., or 3 cu. ft. Using the best materials, this block can be produced for 33 cents, and adding 12 cents for profit and 6 cents for hauling and setting in the wall, makes a total of 51 cents for 3 cu. ft. of wall. A similar amount of brick wall will cost from $.75 to $1.00. Compared with natural stone, the cost is even more favorable; a 5x7 window sill of Indiana limestone will cost in the neighborhood of Washington, D. C., about 35 cents per lineal foot and sells for 45 cents. A sill can be turned out at 12 cents per foot and is sold for 34 cents. An artificial keystone, 4½ ft. long, 14 in. thick, 29 in. wide at the top and 10 in. at the bottom costs about $7.50. A natural stone of the same dimensions costs from $30 to $60.

WINDOW LINTELS FOR POWER STATION

There are 35 of these lintels ten feet long, one foot thick and two feet high, each weighing 4,050 pounds and reinforced by four three-quarter inch steel bars.

The South Norwalk Municipal Plant

SIXTEEN years ago the City of South Norwalk, Conn., was supplied with electric light and power by a local private firm, the Connecticut Lighting & Power Co. Operating without competition, this corporation lighted the streets with unreliable arc lamps of 800 nominal candle-power for periods and at prices arbitrarily fixed to suit its convenience, regardless of public protest and demands for longer and better service.

As a result, after a series of public meetings, the citizens in 1892 voted an appropriation of $22,500 for the establishment of a municipal plant, and a committee of three was appointed by the City Council to direct its construction. Albert E. Winchester, a consulting engineer in New York, was selected to design and supervise the work, and in the course of time he identified himself with the enterprise, making it a life-work. That the South Norwalk plant is highly efficient is due largely to this engineer, who gave up a position of promise and financial success in order to work out to a practical success those principles of public control which appealed to him. How much of the success was due to the system of municipal control, how much to the exceptional individual cannot be determined. It will furnish opponents in argument this ready weapon: "That where a capable individual devotes himself to the principle of public ownership, that force of personal incentive is furnished which is the mainspring of success in private control."

On the land purchased by the committee, a 100-horse-power plant began supplying current to 86 open arc series lamps on city owned pole-lines in October, 1892. The fire-alarm system was transferred from the fire department to the electric works; a departure in public service which has proven advantageous.

After several years of public lighting, the results were so satisfactory that upon a petition to the Council a committee was appointed to report on the advisability of enlarging the plant and extending its service to commercial lighting. Mr. Winchester, then one of the electric light commissioners, was selected to conduct the investigation. After a thorough study covering electric plants in all parts of the United States, a favorable committee report led to an appropriation of $20,000 for a commercial addition in October, 1897. All of this work was designed and supervised by Commissioner Winchester. Commercial lighting began August 1, 1898, and in the following October the most important and distinctive feature of this system was instituted when, with the Council's sanction, all the private and public lighting systems were put on a strictly commercial basis, fixed charges being established for all output of the plant, so as to enable a proper accounting system to be used, as customary under private ownership.

Business increased rapidly, and in May, 1900, $17,500 was appropriated for enlargement, followed by $20,000 in 1903. In the course of these extensions all of the original equipment was retired after eleven years of service. In 1901 the system of the local company was purchased by the commissioners, materially extended and connected with the city's plant. South Norwalk was now operating a complete public and commercial service of light and power, having overcome all competition. This did not occur without opposition on the part of the private company, which was in complete control in 1891. Numerous suits and injunctions, offers to purchase or lease the city plant, and other methods were resorted to. At present, while the opposition company has control of the street-railway system and supplies the city with gas, it actually has but one per cent. of the customers for electric lighting and power.

The municipal service was so satisfactory and the growth of electric demand so rapid that by the end of 1904 the commissioners were confronted with the fact that another enlargement would have to be made to meet the fall load of 1905. The plant had practically outgrown its space limitations. Additional boiler capacity was required if the output was to be increased by adding steam units. This would necessitate the removal of the generating plant to some city property on the water front, where boat delivery of coal could be secured and a supply of circulating water for condensing purposes. In view of the trouble and expense, such a movement was to be avoided if a suitable alternative could be found. After a thorough investigation of existing types of gas, gasoline and fuel-oil engines, it was decided that the installation of an American Diesel engine of 225 horse-power direct connected to a 160 Fort Wayne generator would furnish the required increase of power economically and avoid the necessity of moving the plant. The Council endorsed the commissioners' report advocating the proposed enlargement at a cost of $22,000, and a city meeting appropriated the estimated amount in June, 1905. The material for increasing and extending the distribution system was purchased by the commissioners and the work was completed by the regular operating staff, with temporary help, four months after the enlargement was authorized. The engine and generator were started under trial load.

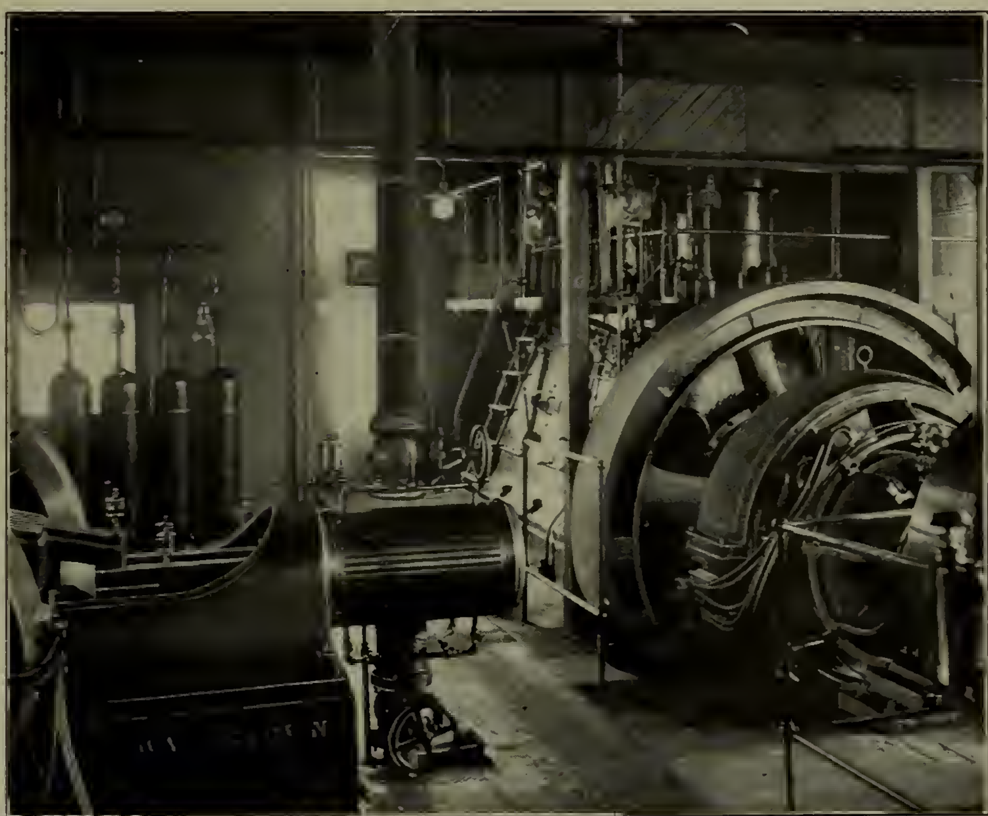
The enterprise of the South Norwalk municipal works system was shown at this time by installing a steam system for heating the passenger coaches of waiting trains of the N. Y., N. H. & H. Railroad Company. Though this forms but a small source of revenue, and makes a market for surplus steam, it shows a degree of initiative and readiness to avail itself of commercial opportunity, wholly at variance with the reluctance to extend and the supine inertia so often incident to municipal control. The same appreciation of technical advances and readiness to discard antiquated equipment and methods may be seen throughout the career of this plant. They prompted the weeding out of the original outfit in 1903, and the radical departure from steam to fuel oil power generation in 1905. The plant is the result of a natural and healthy growth.

After 1898 the enlargements were paid for with notes signed by the commissioners and endorsed by the city treasurer, instead of bond issues. These notes have been, and will be, entirely redeemed by the profits of the plant, which, also, provide for the interest of the debts contracted for the plant's erection and progressive enlargement. For instance, the annual statement of January 1, 1906, reported a debt of $85,400.01, that of January 1, 1907, a debt of $74,694.51, showing a reduction of $10,705.50, all out of the profit of the business. In addition to this $3,445.81 were paid for interest.

PLANT AND EQUIPMENT

Considering the fragmentary growth of this plant, it presents the appearance of a unit conception embodied in one comprehensive design. The main building of brick, 1½ stories high, 109 ft. long, and 48 ft. wide, containing in the fire-room 4 return fire-tubular boilers of 125 nominal horse-power each, a feed-water heater, injector and the ordinary boiler-room appliances, excepting that the unusually complete arrangements for weighing coal indicate an appreciation of systematic and accurate data on fuel consumption.

All the steam engines are of the Watertown high-speed type direct connected to 250 volt direct current, mutipolar generators; two of these are 60-kw. Siemens & Halske, a 280-kw. Eddy and one 165-kw. Fort Wayne dynamo. The Diesel engine shown in Fig. 1 is direct connected to the 165-kw. Fort Wayne generator, which carries the main part of the load. So economical has this engine proven itself that it is run practically all the time and is credited with an average of two-third's the monthly output of the plant. A Norwalk air compressor, belted to a 25 horse-power General Electric 250-volt motor, is used to compress to about 800 pounds per square inch, the air used for injecting the sprayed-fuel oil into the Diesel cylinders. A cylindrical fuel oil storage tank, containing 3350 gallons, is placed under ground close to the plant. From the storage tank the oil is pumped into an accurately gaged distributing tank, which enables positive check to be made on all oil consumed. At the present price of 3¾ cents per gallon, the fuel cost of the Diesel engine generator kilowatt-hour is 3.78 mills. The following data is of interest, as showing the efficiency and economy of the South Norwalk Municipal Electric Works:



225-HORSE-POWER DIESEL OIL ENGINE DIRECT-CONNECTED TO 165-K. W. FORT WAYNE GENERATOR

Average income per Kw. hour	$.04479
Average cost per Kw. hour including int. depr. exp. and opr.	.02764
Average profit Kw. hour	.01715
Gallons of fuel oil consumed last year	59,163
Lbs. coal consumed last year	2,500,810
Average cost of coal per Kw. hour	.02250
Average cost of fuel per Kw. hour	.00359
Average lbs. coal per Kw. hour	8
Average Watt hours per gal. fuel oil	9,916
Average Watt hours per lb. coal	114

The streets are lighted by direct-current series enclosed arc lamps of 1400 nominal c. p. on two circuits, having 13 miles of wire and a total possible capacity of 130 lamps spaced at intervals of 500 ft. The lamps were lighted 357 nights during the past year, each lamp averaging 3287 hours of service at a cost of $.0182 per lamp per hour. The increased economy achieved by the use of the oil engine is shown by the comparison of 246 watts supplied per hour for one cent in 1906 with 191 watts produced in 1905. This record would appear even more favorable had not the Diesel engine been used for 2½ months during the latter year.

The commercial light and power service is continuous—24 hours per day—except during daylight on Sundays. There are 460 light and 60 power customers. The equivalent of approximately 10,000 sixteen-candle-power lamps and motors aggregating 598 horse-power in capacity are connected. The rating of generators is 565 kw. Last year 872,372 kilowatt-hours were generated, 586,872 by the Diesel motor and 285,510 by coal. The average income per kilowatt-hour was 4.479 cents and the cost of generation 2.764 cents. The average cost by fuel oil was 2.25 cents, as compared to 3.59 cents by coal, a difference of 1.32 cents in favor of the Diesel engine, showing that had all the output been generated by coal, the cost would have been $7,746.71 greater than it actually was, and justifying the opinion expressed by the management that the unusual success and economy of this plant was due, in a large degree, to the adoption of the Diesel unit. It is true, however, that these figures do not actually apply to the whole showing, as the cost of coal per kilowatt-hour is disproportionately high, because steam was used as an auxiliary and to carry peak loads only, and entailed the use of a large amount of coal under banked boilers and in getting up fires.

The commissioners estimate that the cost of street lights last year was $5,540, which is $1,526 less than they would have cost if paid for at the rate of $74 per lamp year charged Norwalk by a private company. At the average rate of $83.71 obtaining in Connecticut, the total saving for the city since starting the plant has been $21,478.09. What profits have accrued to private consumers may be judged from the comparison of base rates of 10 cents per kilowatt-hour with 10 per cent. rebate for cash charged by the municipal plant, and 16 cents with 10 per cent. rebate charged by the private lighting company. A comprehensive view of the results obtained by the South Norwalk public works may be obtained from the financial statement published January 1, 1907, as a report of the commissioners to the council and here reproduced.

RESOURCES.

Land and Buildings	$10,391.67
Motive power system	44,521.63
Electric generating system	19,904.31
Distributing system	35,429.85
Miscellaneous equipment	1,525.76
Legal expenses, rights, title	5,639.60
Supplies carried to 1906	370.41
Cash carried to 1906	25.46
1905 accounts receivable	4,792.06
Total	$122,600.35

LIABILITIES.

1892 bonds, street light system	$22,500.00
1898 bonds, commercial system	20,000.00
1900 notes, commercial enlargement	4,000.00
1903 notes, meter installation	4,000.00
1905 notes, commercial enlargement	4,000.00
1905 notes, commercial enlargement	19,000.00
Bills payable	1,194 51
Total debt	$74,694.51
Surplus	47,905.84
Total	$122,600.35

OPERATING EXPENSES.

Repairs	$2,930.81
Interest	3,445.81
Salaries	7,715.97
Fuel	5,907.17
Material and supplies	3,316.69
Miscellaneous Expenses	977.01
Total operating expenses	$24,293.48
Gross gain or profit	14,783.55
Total	$39,077.03

RECEIPTS.	
Municipal lighting (streets and bridge)	$6,640.80
Municipal department lighting	568.20
Commercial light	24,932.04
Commercial power	6,836.00
From loan to 1905 enlargement	99.99
Total	$39,077.03
OPERATING RESOURCES.	
Income for year	$39,077.03
Cash carried over to 1906	308.49
1905 accounts collected	3,377.10
Total	$42,762.62
DISBURSEMENTS.	
Operating expenses (less bills payable)	$23,098.97
New construction account	2,845.55
Reduction of debt (notes taken up)	12,000.00
Cash carried over to 1906	25.06
1905 accounts receivable	4,792.06
Due from fire-alarm appropriation	.98
Total	$42,762.62

In every way this plant has been a source of profit and credit to the community. Directly and indirectly it supplies power to factories furnishing employment to and supporting 2000 people. New industries are being attracted to South Norwalk on account of the low rates charged for light and power. It is almost impossible to find a vacant house at any reasonable price within corporate limits, and new buildings are going up in a number of localities.

The operating staff consists of A. E. Winchester, General Superintendent, City Electrical Engineer and Chief of the Fire Department, 1 clerk, 2 engineers, 2 foremen, a meterman, line foreman, and 1 lineman and trimmer. They are controlled by the three electrical commissioners appointed for a term of three years by the council, which is elected annually. By stipulation and common consent, it is arranged that the electric committee and that in charge of the water-works shall always be divided between the two principal political parties. Thus the electric commissioners are always Democratic by two to one, and the water-works, Republican in the same ratio. This provision is of little practical value or importance. As long as the city's affairs are properly managed it will continue in force, but as soon as incompetence or dishonesty manifest themselves this "gentlemen's agreement" will be disregarded, as it has no sanction in law.

How Leading Central Station Men View the Rate Problem

J. S. CODMAN

UP to the present time, the various papers and discussions of systems of charging for electricity have tended to accentuate strongly the differences in opinion of the writers, and the feeling has arisen that this question is one upon which no two thinkers can agree, and is consequently hopelessly confused. It is a fact, nevertheless, that on the fundamental principles of rate making there is, up to a certain point, a substantial unanimity of opinion amongst those who have thought at all deeply on the subject, and it is the object of this article to show to what extent this unanimity of opinion exists, thereby marking off what has already been accomplished toward the solution of the problem and showing at what point the practical discussion of the question should begin. The writer has endeavored to accomplish this object by a series of quotations from the writings of individuals who have made a special study of the subject, and by references to the rate systems of some of the prominent companies.

These quotations and references are selected to serve as replies to the following questions:

"What is the general opinion in regard to a simple flat rate, that is to say, a charge for capacity only, based on the connected load of the customer?"

"What is the general opinion in regard to a meter rate, that is, a charge for consumption only, based on the reading of a watt-hour or ampere-hour meter?"

"What is the general opinion in regard to a meter rate only, allowing discounts for quantity of consumption?"

"What is the general opinion in regard to 'load-factor' systems, that is, systems which combine a capacity charge and a consumption charge?"

"Assuming that a 'load-factor' system is desirable, what form of it is it best to adopt?"

"Is it advisable to modify the 'load-factor' system by the introduction of the so-called customer's or service charge?"

"With a 'load-factor' system what should be the basis of the capacity charge, that is, what should be taken to constitute the capacity of the customer?"

The foregoing questions will be taken up in order, but before doing so a few words of explanation must be given in order that the quotations may be thoroughly understood.

There are almost as many special systems of charging for electric current in this country as there are companies furnishing current, but there are only two general systems of charging of any importance, one of which alone, or both of which together, form the basis of all the various special rate systems; and it is the failure to fully realize this fact which accounts largely for the prevalent confusion of ideas in regard to the rate problem.

The two systems of charging above mentioned are, first, the flat-rate system or charge on the customer's "capacity" as determined by his connected load, or maximum demand for current, and second, the meter-rate system or charge on the customer's consumption. Both of these systems are simple and easily understood, but neither alone has proved satisfactory. The flat-rate system, inasmuch as it makes no charge for consumption, puts a premium on waste of current and also favors the long-hour user at the expense of the short-hour user. The uniform meter rate, on the other hand, although it stops waste, unduly favors the short-hour user even more, and very much more, than the flat-rate system favors the long-hour user.

By combining the two systems, however, that is, by making a charge on the capacity of the customer and also a charge on his consumption, it is found that the above difficulties can be largely avoided. Waste is prevented by the meter charge while the proper combination of the two charges results in a total charge to each customer closely in proportion to the cost of supplying him, thus avoiding favoring one customer at the expense of another.

Such a combination of the flat-rate and the meter rate is the basis of all the so-called "maximum-demand," "differential" or "load-factor" systems of charging, and the writer will here adopt the latter name as the most descriptive, since with all of these systems the average rate per unit of consumption to each customer depends directly upon his individual load factor.

Although the "load-factor" system of charging avoids the difficulties of the two old systems, its introduction, partly from necessity, was in a form rather difficult to understand, and, furthermore, since its introduction some improvements and details have been added, with the result that its basic principle has been lost sight of to a considerable extent and the whole rate problem thereby made to appear far more difficult and confusing than it really is.

In England the first "load-factor" system introduced—that at Manchester, by Dr. John Hopkinson—was a simple combination of the flat and meter rate; but in the United States the form suggested by Arthur Wright was the first adopted, and both in this country and in England this form is the most commonly used to-day. It is sometimes spoken of as the "two-rate" system, but as there is another system of charging known also as the "two-rate" system,* it is best to speak of the system invented by Mr. Wright as Wright's system. With Wright's system the customer is charged a certain rate per kilowatt-hour, or other unit of consumption, for a consumption up to an amount equivalent to the use of his capacity for a given number of hours per month or per year, and for all consumption in excess a lower rate per unit is charged.

It may be readily shown that Wright's system of charging is identical with the combined capacity charge and consumption charge, or simple "load-factor" system, except for the fact that a maximum rate per unit of consumption is fixed. Suppose, for example, that the capacity charge is $0.15 per 50-watt lamp per month, and the consumption charge is 5 cents per kilowatt-hour. If we figure it out, we shall find that the total charge per kilowatt-hour on a consumption equivalent to the use of the customer's capacity for 10 hours per month will be 35 cents. If then the maximum rate per kilowatt-hour is fixed at 35 cents, the method of charging can be expressed in Wright's manner as follows: 35 cents per kilowatt-hour up to a consumption equivalent to 10 hours' use per month of the capacity and 5 cents per kilowatt-hour on all consumption in excess. If on the other hand the maximum rate is fixed, let us say, at 15 cents per kilowatt-hour, it will be necessary to charge this rate on a consumption equivalent to 30 hours' use of the capacity per month, 5 cents being charged on the excess as before.

One of the reasons for the existence of Wright's form of expressing a "load-factor" system is evidently the desire to fix a maximum rate per unit of consumption. It may be that the maximum rate is fixed by law as was the case at Brighton, England, where Wright's system was first introduced, or it may be that the maximum rate is practically fixed by local custom. Again, it may be thought wise to fix a maximum rate per unit of consumption, even if by doing so it results in furnishing current to the very short hour customers at less than cost, for the reason that these customers are a numerically large body, and the advertising effect of a low rate is therefore valuable, while on the other hand the business obtained from them is of small volume and the loss, therefore, slight and easily made up from the longer hour users. Still again it may be realized that for certain reasons* there undoubtedly is some rate per unit of consumption above which it is not theoretically correct to go even to the shortest hour customers, provided always that they at least pay the cost of connection and of billing, and any other costs due simply to their connection to the service.

The use of Wright's form of "load-factor" system, however, is not the only way of fixing a maximum rate per unit of consumption. It can be done with the simple "load-factor" system by simply offering a uniform meter rate equal to the maximum fixed, as an alternative for the combined capacity and consumption charges; or the capacity and consumption charges can be made with the proviso that should the bill result in a total charge per unit of consumption greater than the maximum fixed upon, then no more than the maximum rate shall be charged. As an example, the following two systems are identical in their effect on the bills, including the limiting of the maximum rate per kilowatt-hour to 15 cents.

SIMPLE LOAD FACTOR SYSTEM

$3.00 per month per kilowatt of capacity.

$0.05 per kilowatt-hour of consumption, with the proviso that the total charge per kilowatt-hour shall not exceed 15 cents.

WRIGHT'S SYSTEM

$0.15 per kilowatt-hour up to a consumption equal to 30 hours monthly use of the capacity.

$0.05 per kilowatt-hour for all additional current.

If the only object in adopting Wright's method of expressing a "load-factor" system were to fix a maximum rate per kilowatt-hour there would be little to recommend it since the statement of it is not nearly as easily understood as that of the simple load-factor system with the proviso given above. In the first place the usual statement of Wright's system, namely, "that the high rate is charged for so many hours' use of the capacity," is inaccurate and misleading; but the correct statement, namely, that the high rate is charged for a consumption equivalent to so many hours' use of the capacity, is very cumbersome.

The following modifications of Wright's system, however, although no less unwieldy than the latter, are nevertheless a little more easily understood. To illustrate, the following examples of Wright's system and modifications of it are identical in their effect on the bills:

WRIGHT'S SYSTEM

Primary rate of 15 cents per kilowatt-hour up to a consumption equal to 30 hours' use per month of the capacity and 5 cents for the balance.

FIRST MODIFICATION

Primary rate of 15 cents per kilowatt-hour up to a consumption equal to 1½ kilowatt-hours per 50-watt lamp of capacity (or 30 kilowatt-hours per kilowatt of capacity) per month and 5 cents for the balance.

SECOND MODIFICATION

Primary rate of 15 cents per kilowatt-hour until the monthly bill reaches 22½ cents per 50-watt lamp of capacity (or $4.50 per kilowatt of capacity) per month and 5 cents for the balance.

Probably in the majority of cases where Wright's system is in use, its adoption was due to the fact that a maximum rate per kilowatt-hour was already fixed, but another reason for it has been the desire to avoid the appearance of a capacity charge. This latter object it accomplishes satisfactorily, and in some cases the result is

*The original "two-rate" system is one under which the customer is charged a high rate for electricity consumed during certain hours of the day when the plant is heavily loaded, that is, during the peak hours, and is charged a lower rate during the other hours. As a system it is now practically obsolete, but the general principle upon which it is based is still frequently made use of in the treatment of special customers.

*See "Discrimination in Rates," by J. S. Codman, page 12, read before the Association of Electric Lighting Engineers of New England, March 21, 1906, and published in full in "The Electrical Age" for June, 1906. See page 413, columns 1 and 2.

undoubtedly desirable, at least at the present time. Nevertheless, in the opinion of the writer, in the long run it will pay to make the capacity charge plainly, and to fight for its recognition as just and equitable. With the right to make a capacity charge definitely established and the public once accustomed to it, the differences in the average rate per kilowatt-hour between different customers will not be so noticeable, but if noticed, the reason for the differences will be plain. Furthermore, whenever it is necessary to explain a "load-factor" system to the customers or to municipal or State authorities, the simple "load-factor" system, with capacity charge apparent, is more easily understood. In fact, if Wright's system is adopted, it will generally be found necessary, in order to explain it, to convert it into the simple "load-factor" system and then to show how Wright's system is derived from the latter.

Of course, in places where a meter rate only has been in force for a long time and flat rates have been forgotten, it is a difficult thing to introduce a capacity charge, but, on the other hand, where flat rates have not altogether gone out, or are of the recent past, it should not be a difficult matter to reintroduce them combined with a meter charge. That the capacity charge can be used successfully without any attempt to conceal it, is proved by the number of companies which have adopted it, notably the plants of the American Light & Traction Co., where Henry L. Doherty's "Readiness-to-Serve" system is in use.

It is a curious fact that while the greater number of electric lighting companies having "load-factor" systems use Wright's form, that is, make the unit of consumption apparently the only basis of charge, among the companies selling power from Niagara Falls a "load-factor" system of charging prevails which keeps the unit of consumption entirely out of sight and apparently makes the capacity the sole basis of charge. The following statement of the Niagara system, using specific figures, is identical in its effect on the bills with the statements of the simple load-factor system and Wright's system with the modifications already given.

NIAGARA SYSTEM

$3.00 per kilowatt per month, plus $33.00 per kilowatt per month multiplied by the load factor. In this expression the load factor is taken as the ratio of the actual consumption in kilowatt-hours to 720 times the capacity in kilowatts, 720 being the number of hours in a month.

An addition to the load-factor system which has complicated the discussion of it to a certain extent has been the introduction by Henry L. Doherty in his "Readiness-to-Serve" system of a customer's service charge, in addition to the capacity charge and the consumption charge.

This charge, as the writer has already pointed out on a previous occasion,* is absolutely logical for the reason that certain expenses are proportional to the number of customers rather than to their capacity or consumption, and the addition of this charge is theoretically an improvement on the load-factor system. Whether or not it is expedient to make this charge is a question of whether the additional complication is advisable, considering that the expenses proportional to the number of customers are of small account, probably not more than 10 per cent. of the total. At any rate, the additional complication does not appear to have prevented its success in the numerous cities where it has been tried.

Except with the "Readiness-to-Serve" system, however, this consumer's charge, so far as the writer knows, has never been made, although there is no essential reason why it should not be adopted with any load-factor system, even when expressed in Wright's manner. To make this clear, let us consider the rates of a prominent company using the "Readiness-to-Serve" system. These rates are 15 cents per 50-watt lamp of capacity per month, 5 cents per kilowatt-hour and $1.00 per month as a service charge, with an alternative uniform meter rate of 10 cents per kilowatt-hour. The same results can be obtained by expressing this in Wright's manner as follows: 10 cents a kilowatt-hour up to a consumption equivalent to 60 hours' use per month of capacity and 5 cents for all consumption in excess, with a service charge of $1.00 per month.

As already stated, so far as the writer knows, this customer's charge has never been made a distinctly separate charge except with the "Readiness-to-Serve" system, but the fact that a certain charge ought to be made to each customer without regard to his capacity or consumption has been recognized by most companies and has been partly taken care of by the use of a minimum bill. The only advantage of the minimum bill over the customer's or service charge is that it is simpler.

Another cause of confusion in the discussion of load-factor systems is due to the fact that simultaneously

*See "Discrimination in Rates," page 15, or "The Electrical Age" for June, 1906, page 414, column 1.

with their introduction it was pointed out that the connected load of the customer, which up to that time had been considered the "capacity" of the customer, was not a proper basis of charge.

Arthur Wright, with the introduction of his system at Brighton, England, introduced the maximum demand as the basis of the capacity charge, and since then it has been quite generally recognized that the maximum demand is the proper basis of charge. Just what shall constitute this maximum demand, however, is still a debatable question, and one about which there is great difference of opinion. The writer has gone into this question at considerable length elsewhere,* and there was a good discussion of the question in the report of the Committee on Rates and Costs presented last June at the convention of the National Electric Light Association.

Having now pointed out that the different load-factor systems are fundamentally the same because they all practically consist of a combined capacity and consumption charge, we can return to the questions already propounded and determine the answers from the quotations to follow.

"What is the general opinion in regard to a simple flat rate, that is to say a charge for capacity only based on the "connected load" of the customer?"

H. L. Doherty:

"Flat rates do not, I think, have a single prominent advocate."

"Equitable, Uniform & Competitive Rates," National Electric Light Association, May, 1900, page 6.

Arthur Wright:

"Thus the old tariff of a fixed price per lamp per annum was nearly as unsound as that of a uniform charge per unit has been shown to be."

"Some Principles Underlying the Profitable Sale of Electricity." Paper before Institution of Electrical Engineers, England, 1901, page 35.

L. A. Ferguson:

"We find that the more progressive companies have abandoned the old methods of selling electricity at a flat amount per month or on a basis of discount for quantity only, and have adopted some more equitable method of charging."

National Electric Light Association, Transactions of 25th Convention, 1902, page 416.

*See "Discrimination in Rates," page 16 or "The Electrical Age" for June, 1906, page 414, second column.

E. F. Phillips:

"Flat rates have never seemed to us just or equitable, and, therefore, appeared to be an unwise business proposition."

National Electric Light Association, Transactions of 25th Convention, 1902, page 436.

H. C. Ayers:

"The objections to the flat rate are pretty well known to most central station managers; the principal one is, of course, that your customers will waste current."

"Selling Current to Cities of 20,000 inhabitants," Ohio Electric Light Association, August, 1905; see *The Electric Journal*, page 354.

S. B. Storer:

"At first, in the absence of any measuring instruments, the flat rate was the only method. This was soon found to be impracticable for most cases."

"The Sale and Measurements of Electric Power," 1906.

The above quotations all refer to the electric light business, but the opinions of some of the prominent gas engineers in regard to their business are also interesting.

W. H. Gardiner:

"The system of paying so much per month per location is evidently less desirable than even the 'uniform rate by meter,' although if it could be developed with some considerable degree of justice, it would, from the managerial point of view, have many points in its favor.

"The Making of Rates and the Additional Business System of Costs," Western Gas Association, 29th meeting, May, 1906, page 22.

F. W. Frueauff:

"This method proved extremely unsatisfactory for both the companies and the consumers."

"Methods of Charging for Gas," American Gas Light Association, October, 1904, page 114.

"What is the general opinion in regard to a uniform meter rate, that is, a charge for consumption only, based on the reading of a watt-hour or ampere-hour meter?"

W. D. Marks:

"Still the meter alone without any contract has its disadvantages."

"How to get Paying Loads for Stations," Association of Edison Cos., 1891.

Arthur Wright:

"A uniform price to all classes involves the long-hour consumer paying for the loss made on the short-hour consumer."

"This taxing of the good load-factor consumer for the benefit of the bad one must encourage the latter and seriously discourage the former, which obviously implies an unnecessarily poor load factor for the whole undertaking, which in turn raises the average cost."

"Some Principles Underlying the Profitable Sale of Electricity;" page 29.

H. L. Doherty:

. . . "as any system is better than the uniform kilowatt-hour system. I think the uniform system can hardly be classed as anything less than absurd."

National Electric Light Association, Transactions of 25th Convention, 1902, page 462.

Alexander Dow:

"Mr. Doherty's premises are correct. His deduction therefrom that the sale of current at a fixed rate per kilowatt hour is as inequitable as the sale of current at a fixed charge per lamp is fully warranted by the premises."

"National Electric Light Association, Transactions of 25th Convention, 1902, page 441.

L. R. Wallis:

"It results in a selling price directly favoring the short-hour consumer and positively prohibitory to the long-hour consumer."

"The Foresee System of Charging," National Electric Light Association, 1901.

L. A. Ferguson:

"Such a uniform kilowatt-hour price requires the company to sell its product to some classes of customers at an absolute loss and prevents it from supplying its product to other consumers from whom it might obtain a profit, at a price lower than the price required by the municipal or State law."

National Electric Light Association, Transactions of 25th Convention, 1902, pages 418 and 419.

E. F. Phillips:

"Regarding the uniform meter rates, it became evident several years ago that if we desired to extend our business to any considerable extent, or to popularize the use of electricity, some reductions would have to be made or other methods adopted."

National Electric Light Association, Transactions of 25th Convention, 1902, page 437.

Arthur Williams:

"I want to suggest a method of charging, which, in view of what has been said, I am afraid will be at the moment unpopular. It is the adoption of a flat kilowatt-hour rate, without discount, for all electric current supplied from the works. A rate on one scale would be appropriate for retail or limited users of light, another designed for competition with isolated plants for the larger users where the costs of supply are proportionately less; a third power rate is also desirable, which might be subdivided, wholesale and retail."

National Electric Light Association, Transactions of 25th Convention, 1902, page 444.

It will be seen that even Mr. Williams does not advocate a uniform rate per kilowatt-hour to everyone.

John F. Gilchrist:

"I think we will all admit that we have wished that our business were such that a uniform price, as suggested by Mr. Williams, might be charged; that is, without even dividing it into wholesale and retail quantities; that we might manufacture electricity as the gas companies manufacture gas—to sell it uniformly at so much per unit; but such is not the case. I think that New York conditions may tend more toward permitting that kind of rate than the conditions of any other city or town in this country."

National Electric Light Association, Transactions of 25th Convention, 1902, page 448.

S. B. Storer:

"This method is still in very general use in its simplest form, but there has been dissatisfaction with it from the start."

"The Sale and Measurement of Electric Power," 1906.

A. S. Knight:

"An average price to everybody never could be low enough to secure the long-use business, without which the company would only occupy a very limited portion of the field, restricting its growth and development so seriously that reductions in prices would be confined to very narrow limits."

"Explanation of Edison Co.'s System of Differential Charges for Electricity in Boston," March, 1906, page 3.

H. C. Ayers:

"The objections to a straight-meter basis are, that it does not accurately distribute among your customers their proportionate share of the costs of supplying them and will always cause some customers to be operated at a loss to the company and others to pay in excess by an amount which makes up their deficiency, or in other words, the one customer is helping pay the other customer's light bill, and this system discriminates against the long-hour user who is by all odds the more desirable customer, and the one the station wants."

"Selling Current to Cities of 20,000 Inhabitants," page 2.

The next quotation shows that uniform-meter rates, even in the gas business, are not accepted by every engineer. Mr. Gardiner is not alone in this opinion.

W. H. Gardiner:

"The system of charging for gas—say, one doller per thousand cubic feet regardless of any other consideration—is familiar to everyone, and has merely its simplicity to commend it, the ease with which the public can understand it, and the minimum difficulty of accounting which it entails. It is, however, in the opinion of the author, one of the most unjust, inequitable and undesirable systems, both from the viewpoint of the public and that of the corporation, that has ever been in use.

"In the ultimate analysis, therefore, the uniform rate by meter can justify its existence solely on the facts that it does exist, and because it is simple and easily grasped by the public. As suggested before, it would be hard to conceive of a system more detrimental to the best interests of the community at large."

"The Making of Rates and the Additional Business System of Costs," page 20 and 21.

"What is the general opinion in regard to a meter rate allowing discounts for quantity of consumption?"

Henry L. Doherty:

"They do not, I think, have a single prominent advocate."

"Equitable, Uniform and Competitive Rates," National Electric Light Association, 1900, page 6.

Arthur Wright:

"The bad effects of the flat-rate system (uniform meter rate system) are further accentuated by the custom of working it in conjunction with a system of discounts to large annual consumers, based on the fallacious assumption that larger consumption necessarily involves greater profit. This indiscriminate discount to large consumers is another mischievous inheritance from the erroneous analogy of the gas business."

"Some Principles Underlying the Profitable Sale of Electricity," page 30.

W. J. Greene:

"It is also possible to make concessions without encountering the dangers to be met with in discounting all bills of a certain amount or over, as where all bills of, say, $10 per month or over, are discounted, a consumer having 100 lights and a bill of only $10 a month will get a discount, whereas he should have created a bill of $20 to $30 per month, before he had reimbursed the company for expenses actually incurred in order to provide him with light subject to his voluntary use."

Electrical World, February 29, 1896, page 223.

L. R. Wallis:

"Discounts based upon quantity of current used do not, as we all know, meet the exigency, as they discriminate only on total quantity of current used and do not take into consideration whether it is the result of the use of a large installation for a few hours or of a small installation for a number of hours."

"The Foresee System of Charging."

Mr. Gardiner in the following refers to both the gas and electric business.

W. H. Gardiner:

"The Quantity Increment System, however, falls down absolutely when it comes to penalizing extremely short-hour burning customers with high maximum demands.

"Therefore, in part its range of differentiation cannot be nearly as wide, nor is it, in fact, as rapid as those given by some of the rate systems previously outlined, consequently it cannot be compared with them as a business getter.

"Furthermore, as its price bears but a very remote and intangible relation to any cost curve, it has but slight grounds of individual equity when compared with these other rate systems."

"The Making of Rates and the Additional Business Systems of Cost," page 19.

"What is the general opinion in regard to load-factor systems, that is, systems which combine a capacity charge and a consumption charge?"

Dr. John Hopkinson:

"The ideal method of charge, then, is a fixed charge per quarter proportioned to the greatest rate of supply the consumer will ever take, and a charge by meter for the actual consumption."

Presidential address November 4, 1892, Junior Engineering Society, published in London *Electrician,* November 11, 1892.

Arthur Wright:

"It now seems hopeless in some districts entirely to resist the demand for electricity charges being based on the units consumed instead of on the commercially sound principle of a charge compounded of kilowatts demanded and units consumed."

"Some Principles Underlying the Profitable Sale of Electricity," page 26.

L. R. Wallis:

"The idea of a combined contract and meter system is broadly the end toward which all practical methods are tending."

"The Foresee System of Charging."

H. C. Ayers:

"A rate may be adopted consisting of a fixed charge and a charge for current as shown by meter, which will have the following advantages."

"Selling Current to Cities of 20,000 Inhabitants," page 356.

M. E. Turner:

"As to a schedule of tariff, any system can be used which obtains the necessary income for the hour's use of the capacity installed provided for in its costs, whether this system be a straight fixed charge of so much per annum and a small running charge, a system of discounts equivalent to hour's use, or the two-rate* system."

"Graded Costs of Electric Supply," Ohio Electric Light Association, August, 1904.

R. S. Hale:

"It is apparent that some system of charging is needed which will draw a profit from the short-hour customers without making them feel that they are unfairly treated, and will give a low price to those customers who use their proportion of the plant long hours."

"Charge for Electric Current on the Wright Demand System," Electrical Engineer, October 21, 1896, page 392.

Samuel Scovil:

"I assume that it will be conceded by all central station managers who have studied the subject, that the cost of service to the consumer should be based in the main on the hour's use of the capacity demanded by him, and that the tariff schedule should be proportional to the costs."

National Electric Light Association, 25th Convention, 1902, page 435.

John F. Gilchrist:

"We must, in the opinion of most of us, have a system that will charge a higher rate to short-hour consumers

*Mr. Turner here refers to Wright's system of high primary rate and a low secondary rate for kilowatt-hour, not to the two-rate system described in foot-note on a preceding page.

and a lower rate to long-hour consumers, on account of the station investment, which may be the same in both cases, although the consumption will be very different."

National Electric Light Association, 25th Convention, 1902, page 448.

S. B. Storer:

"It is fully recognized now, however, that the load factor is the root of the trouble, and unless a system of charging gives due consideration to it there will always be inequality of rates and dissatisfaction on the part of the power company or of its customers, or of both."

"The Sale and Measurement of Electric Power," page 1.

W. J. Greene:

"This method is not as popular with short-hour consumers as the plan of charging a fixed rate per unit, regardless of consumption; but the plan is, without question, more equitable and just to all concerned."

Electrical World, vol. XXVII No. 9, February 29, 1896, page 223.

A. S. Knight:

"The differential price tariff is theoretically correct, because each step under this tariff is practically proportional to the cost of supplying customers at that point."

"Explanation Edison Co.'s System of Differential Charges for Electricity in Boston," March, 1906, page 4.

L. A. Ferguson:

"Our success with the load-factor and minimum guarantee systems, as employed with the large consumers, together with the full realization of the principles underlying the cost of supplying each customer, led us, in 1897, to adopt for all our new business and for the gradual readjustment of our existing business the Wright Demand System in a modified form."

National Electric Light Association, 25th Convention, 1902, page 425.

H. L. Doherty:

"The system of rates that I advocate is based on, first, the expenses due to taking care of the consumers' accounts, and other similar expenses; second, the expenses occasioned by the capacity that the consumer demands, and, third, the expenses occasioned by the amount of current consumed. The charge might be outlined as (1) the consumer or meter charge; (2) capacity charge; and (3) current charge."

National Electric Light Association, 25th Convention, 1902, page 403.

The above-described system is clearly a load-factor system with the addition of a consumer's charge.

The above quotations show that expert opinion is practically unanimous in regarding the old "contract" or "flat" rate and also the meter rate, either with or without discounts for quantity, as unsatisfactory for the electric business to-day, and that in place of them a load-factor system of some kind should be used. Furthermore, a large number of electric light companies have already adopted the load-factor principle in their rate systems and this number includes nearly all the very prominent companies, such as those in New York, Chicago, Boston, Philadelphia, St. Louis, Detroit, Minneapolis, St. Paul, Cleveland, Cincinnati, Baltimore, Washington and Denver, as well as a steadily increasing number of the smaller companies.

There is substantial agreement then so far, but with the next question opinions begin to diverge.

"Assuming that a load-factor system is desirable, what form of it is it best to adopt?"

This question is best answered not by quoting opinions, but by pointing out what forms have been most widely adopted. There is no doubt that at the present time, as already stated, Wright's original form is the most widely used form of load-factor system, both here and in England. This, however, is probably not because the majority of opinion considers it intrinsically the best system, but its adoption has been due in very many cases to the local conditions. These governing local conditions have already been mentioned and it is hardly necessary to enlarge upon them further here.

As to the next question: *"Is it advisable to modify the load-factor system by the introduction of the so-called customer's charge or service charge?"* the answer has already been given. There is not very much difference of opinion about it. In the majority of cases this charge is not directly made, but its justice is probably recognized by all authorities, and if the charge is not directly made, at least some approximate method of taking care of it has been adopted. In fact, the answer to all the questions discussed above is that there is not much real conflict of opinion among authorities, but when we come to the last question this is no longer the case."

"With a load-factor system, what shall be the basis of the capacity charge, that is, what shall be taken to constitute the capacity of the customer, and how shall it be determined?"

As regards this question, there is a wide difference of opinion, but if the writer has shown that up to this point there is substantial unanimity of opinion and that consequently the practical discussion of rate systems begins at this point, he has accomplished his object and need go no further. Discussion of this question is not within the scope of this paper, but articles referring to it have already been mentioned.

A Vital Electric Traction Problem

In view of the recent steps taken in the adoption of electricity in dealing with the dense traffic handled at important railroad terminals, and the recent unfortunate accident at a curve on the Harlem Division of the New York Central and Hudson River Railroad, it is of importance that the question should be settled as to whether the present methods of track construction are suited to use with heavy electric locomotives. In order to do this the probable and known effects of both types of locomotive upon track and roadbed must be analyzed and compared, particularly upon curves. It has been endeavored to do this, using types of locomotive used by the New York Central for the purpose. In making this comparison the working drawings were not available, which necessarily was something of a handicap, and while this may cause a certain amount of inaccuracy in the numerical computations, it does not in any way affect the line of reasoning or the methods employed.

The New York Central accident occurred on a 3°-5′ curve, having a radius of 1858.5 feet, the superelevation of the outer rail was 4½ ins. The track is laid with 100-lb. rails and twenty ties are used per rail length, being spaced about 21 ins. centers. The rail are spiked down with one spike on each side of each rail and tie plates are used. The ties were of yellow pine, chestnut and oak bedded in broken stone ballast to their full depth. From the standpoint of the railroad manager the track construction is of modern type, of the heaviest construction and thoroughly adapted to high-speed traffic. In considering the roadbed question it must be remembered that, with the exception of heavier rails, an increased number of ties per mile, the use of broken stone ballast and slightly larger spikes, the method of construction used to-day remains the same as it was thirty years ago. In the meantime the weight of locomotives and other rolling stock has been largely increased and the operating speeds have risen, and a large number of trains attain, on portions of their run, speeds exceeding fifty miles per hour, and some trains on long runs are scheduled at such speeds.

The description of the track at the point where the accident occurred is transcribed from the testimony brought out at the subsequent investigation, and the following was derived from the same source. There were no rail braces used on the outer rail, and the speed scheduled was 57.6 miles per hour. The speed of the train to which the accident occurred was between 50 and 60 miles per hour according to the motorman and an inspector riding in the cab, and 70 miles per hour according to the testimony of passengers.

The track was laid with tie plates, and while these act to hold the spikes up to the rail and to prevent the rail from cutting into the tie, they at the same time reduce the frictional resistance with which the rail resists lateral displacement. A point that must be considered is that the weight upon the rail is an important factor in holding it in place.

All track is more or less flexible and, except when the ties are frozen fast in the ballast, a wave or vertical deflection can be seen under each wheel. This working of the track under traffic is liable to loosen ties from the ballast, and in thawing weather, track in the sunshine will become soft while that sheltered under a bridge will remain hard. Also after sunset the sheltered track will not get hard as quick as that fully exposed. The rail that was forced out of the track is immediately under the north edge of a bridge where it would be sheltered from the sun. On the morning of the day upon which the accident occurred a report was made of "rough track" at about this point, but inspection by a section foreman detected no defect. This report was turned in about eight hours before the accident.

One of the points well known, to those having to maintain tracks, is the continual tendency of curves to get out of line; and the use of transition spirals, while it tends to reduce this trouble, cannot entirely obviate it.

In some of the test runs of the electric locomotive, on the trial track, near Schenectady, as reported in the *Railroad Gazette* of May 26, 1905, a 2° 17′ curve was taken at a speed of 78 miles per hour by the light locomotive; and it is was observed that the entire track shifted in the ballast. This shifting was laid to insufficient superelevation on the curve. According to the testimony of Mr. W. J. Wilgus, vice-president of the railroad, in reply to a question as to whether there was any spreading of the rails upon the experimental track, there was not exactly a spreading of the rails, but there was an oscillation which stretched the tracks out of gauge at occasional points. All that was later obviated." Mr. Wilgus also stated that this tendency of the rails to spread was not on the curves but on tangents. With wooden ties it is well known that the outward forces on curves rapidly pulverizes wood under the outer edge of the rail flange and necessitates the trackmen adzing the tie off to get a new bearing surface. These forces have also been known to attain sufficient intensity to slide the rail along the ties, crushing the spike into the wood, and in some cases partly pulling them. The rail also tends to deflect or spring more or less between the spikes, and in the course of time the flange of the rail cuts or wears a groove in the spike immediately under its head. This wearing occurs more rapidly under heavy high-speed traffic than under other conditions, and is well known to experienced track men. Such grooves will greatly weaken the spike as regards its shearing resistance.

Upon the curves the outer rail is elevated in order to partly counteract the centrifugal force tending to throw the moving train off at a tangent. According to "Trautwine's Pocketbook," the rule of thumb for superelevation is one inch for each degree of curvature for speeds under 60 miles per hour, but this should be increased at points exposed to high winds. The exact formula for the amount of superelevation, from the same work, is:

$$\frac{v^2 G}{R g} = e$$

in which

e=superelevation of outer rail in inches.

v=velocity of train in feet per second.

G=gauge of track in inches.

R=radius of curve in feet.

g=gravity=32.2.

According to this formula, for a speed of 60 miles per hour, the superelevation of the outer rail should be 7.31 in. instead of the 4½ in. as measured. The equilibrium speed for a superelevation of 4½ in. is 47 miles per hour. The speed scheduled at this point according to the testimony was 57.6 miles per hour.

The train to which the accident occurred consisted of five coaches and two electric locomotives. Two locomotives being used owing to the fact that the contact shoes on one side of each locomotive had been broken off; the shoes on one locomotive were on the opposite side to those on the other, and as the contact rail is not continuous on one side of the track, being broken at cross-overs and turnouts, it was necessary to use both locomotives in order to avoid danger of the train stalling at such a gap in the contact rail. The use of the two locomotives does not affect the stresses produced in the track.

According to Mr. C. H. Quereau, superintendent of electrical equipment, the weight of the wrecked train was 335.25 tons. In the tests at Schenectady a speed of 61.6 miles per hour was reached with a train weighing 407.5 tons, and on another occasion 60 miles per hour was reached with a train weighing 513.6 tons. The maximum speed reached by the electric locomotive was 85 miles per hour. In the published reports of these tests no mention is made of the apparatus or methods used to determine the speeds attained, but it is presumable that accurate methods were used, and that the speed was not judged by the locomotive runner's standard, the number of telegraph poles passed in a guessed interval of time. Although the speed of the train was testified to as being from 50 to 60 miles per hour, the fact that the electric locomotive rides very easily makes it quite possible that the actual speed at the moment was much higher; in fact, the tendency of those riding is to underestimate the speed of motion.

The electric locomotives used by the New York Central were designed and built by the American Locomotive Co. and the General Electric Co. They are of the 2-8-2 type.

N. Y. C. ELECTRIC LOCOMOTIVE DIMENSIONS

(*Eng. News. Nov.* 16, 1905)

GENERAL—	
Class of traffic	Fast passenger
Gauge, standard	4 ft. 8½ in.
Total length over buffer platforms	37 ft.
Extreme width	10 ft.
RUNNING GEAR—	
Driving wheels, 8, diameter	44 in.
Truck wheels, 2 front, 2 rear, diameter	36 in.
Trucks	Centered by springs
Diameter of driving axles	8½ in.
WHEEL BASE—	
Driving	13 ft.
Total	27 ft.
WEIGHT—	
On driving wheels	137,000 lbs.
On truck wheels	52,000 lbs.
Total in working order	189,000 lbs.
POWER—	
Supply, direct current	600 volts
Conductors	Overhead and third rail
Motors, four GE-84-A, each 550 h.p	2,200 h.p. rated
Maximum power of locomotive	3,000 h. p.
Normal full-load current	3050 amp.
Maximum current	4,300 amp.
Normal drawbar pull	20.400 lbs.

Maximum starting drawbar pull.................... 32,000 lbs.
Speed with 500 ton train, on level.................... 60 mi. per hr.
Control: Sprague-General Electric multiple unit, with automatic current-limiting lock in the master controller. Series-parallel, from four motors in series to four in parallel.

The locomotive was designed to enable an acceleration of 0.5 to 1.0 mile per hour per second to be obtained with trains up to 800 tons and to give a maximum speed of 60 miles per hour with a 500-ton train. In actual test on a 4-mile track near Schenectady the results in both speed and acceleration were, it is reported, wholly satisfactory.

The two-wheel trucks at either end are connected to the main frame by a radius arm, and owing to the short wheel base the locomotive is very flexible laterally.

The steam locomotives used for the fast trains are of the 4-4-2 type.

In Fig. 1 a graphical comparison is made, showing approximately the distance from the top of the rail to the centers of gravity and the location of the points of spring suspension with reference to their centers of gravity for the steam and electric locomotives. The triangle CGS, SPS, SPS' being for the steam and CGE, SPE, SPE' being for the electric machine. The effect of this spring suspension is to introduce a certain amount of pendulum action in the side sway of the two machines, also the centrifugal force of the suspended weight has a tendency to move it entirely independent of the running gear. This side force can be resolved into two components with regard to its effects, one of them tending to compress the springs on one side of the machine and to lessen the load on the opposite spring. The other component being a force parallel to the tops of the rails and tending to force the outer rail on a curve outward or on a tangent to spread the rails.

The difference in the method of suspension of the two machines arises from their mechanical differences. In the steam locomotive the journals on the driving axles are located between the wheels, which brings them very close together. In the electric locomotive the space between the wheels is entirely occupied by the motors, hence the journals are outside of the wheels, and nearly twice the distance apart of those for the steam locomotive. At the same time the center of gravity of the electric machine is much closer to the top of the rails than that of the steam machine. While this low center of gravity makes the electric locomotive less liable to upset and reduces the effect of the side lurches in their effect upon those riding in the machine, the horizontal impact of the machine against the side of the rail will be somewhat greater than for a steam locomotive, as the largest component of the force of these lurches causes side pressure and tends to displace the outside rail on the track laterally.

The centrifugal force of a body moving in a curved path can be computed by the formula,

$$\frac{W\ v^2}{R\ g} = F$$

In which

F=the horizontal centrifugal force in pounds.

W=the weight of the moving body in pounds.

V=velocity of the moving body in feet per second.

R=radius of the curved path in feet.

g=gravity=32.2.

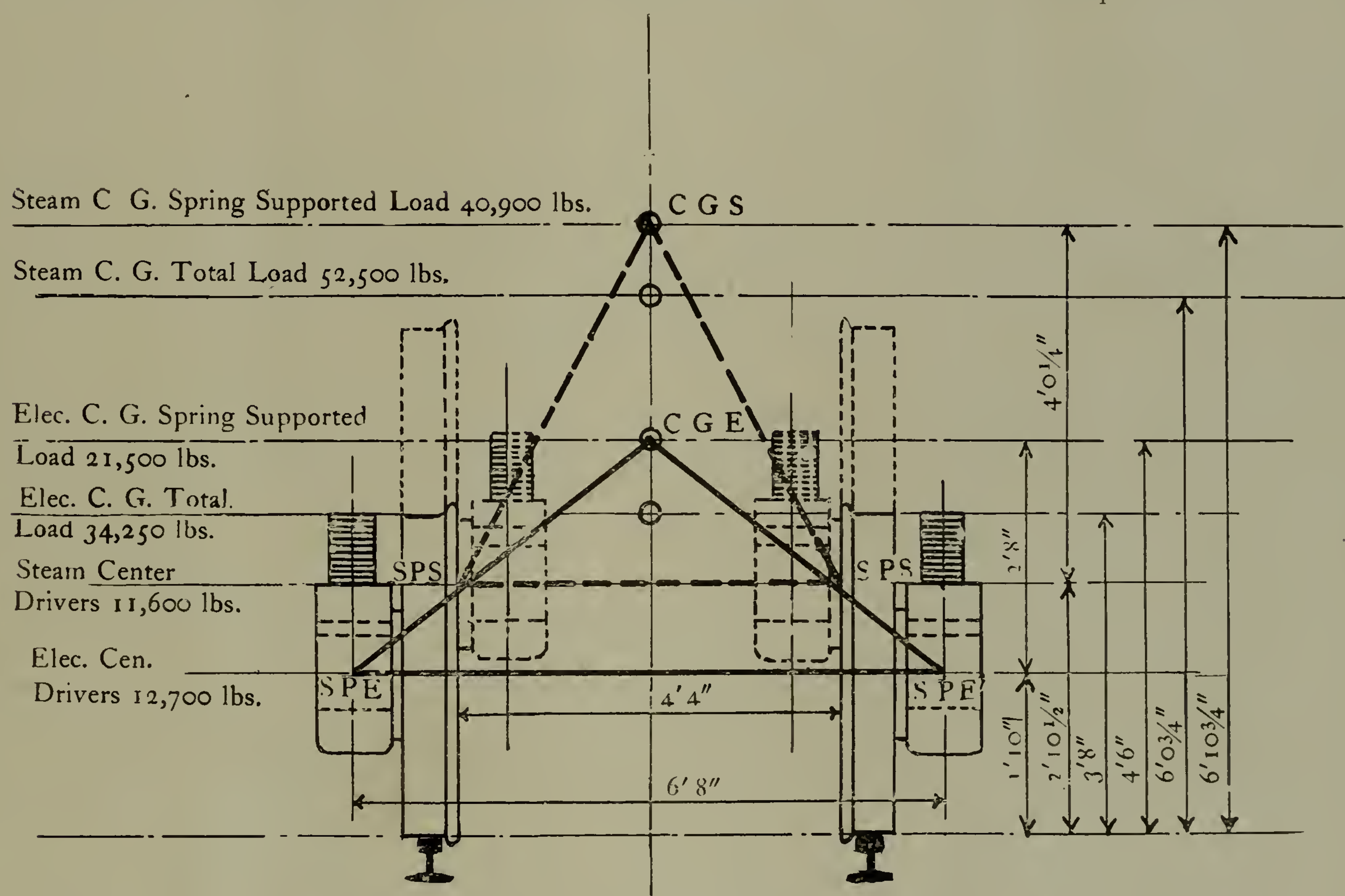


FIG. 1.—GRAPHICAL COMPARISON OF THE LOCATION OF THE CENTERS OF GRAVITY AND POINTS OF SUPPORT OF THE STEAM AND ELECTRIC LOCOMOTIVES USED BY THE NEW YORK CENTRAL AND HUDSON RIVER RAILROAD. FULL LINES ELECTRIC LOCOMOTIVE. DOTTED LINES STEAM LOCOMOTIVE.

The following table computed by this formula gives the horizontal centrifugal force generated by the axle loads of steam and electric locomotives in passing around a 3° 5′ curve at different velocities reduced by the effect of gravity due to 4½ and 7.31 inches superelevation:

CENTRIFUGAL FORCE DUE TO TOTAL WEIGHT ON AXLE IN POUNDS

	Electric Drivers		Steam Drivers	
Speed Mi. per hr.	4½″ Elev.	7.31″ Elev.	4½″ Elev.	7.31″ Elev.
50	335	−1,395	513	−2,027
60	1,692	− 28	2,593	− 47
70	3.284	+1,564	5.035	+2,395
80	5,161	+3,441	7,912	+5,272

The above forces can be resolved into two components, one producing pressure on the top of the rail, the other pressure on the side of the rail tending to force it laterally out of position. These force components are tabulated below for superelevations of 4.5 and 7.31 in.

CENTRIFUGAL FORCE IN POUNDS PARALLEL TO TOPS OF RAILS

	Superelevation 7.31 in.		Superelevation 4.5 in.	
Speed Mi. per hr.	Electric Drivers	Steam Drivers	Electric Drivers	Steam Drivers
50	−1,380	−2,010	334	511
60	− 28	− 47	1,687	2,585
70	+1,550	+2,380	3,275	5,020
80	+3,415	+5,230	5,144	7,895

CENTRIFUGAL FORCE IN POUNDS, PRESSURE ON TOP OF RAIL

	Superelevation 7.31 in.		Superelevation 4.5 in.	
Speed Mi. per hr.	Electric Drivers	Steam Drivers	Electric Drivers	Steam Drivers
50	−180	−254	27	41
60	− 4	− 6	135	207
70	+200	+312	263	402
80	+447	+688	413	633

The foregoing tables are of interest in regard to the total difference between the two types of locomotives. In the electric locomotive the spring supported load is 21,500 lbs. compared with 40,900 lbs. in the steam machine; the weight of the drivers, armatures and axle being, in the former, 12,750 lbs. against 11,600 lbs. for the drivers and axle of the latter. From this it can be seen that the gyroscopic action would be very nearly equal, as would flange pressure due to the weight of these parts. Therefore any difference in the action of the machines must be due to the spring supported weight and the method by which it is hung, as is shown in the diagram. The following table compares the centrifugal force due to the normal spring supported weight on the driving axles of both locomotives together with the component of this force which would pass into the springs and become vertical pressure on the rail on a curve of 3° 5′ with 4.5 in. superelevation:

	Centrifugal Force		Component on Springs	
Speed Mi. per hr.	Electric Drivers	Steam Drivers	Electric Drivers	Steam Drivers
50	210	421	80	390
60	1,062	2,046	424	1,810
70	2,062	3,936	824	3,670
80	3,240	6,199	1,300	5,740

The force of the blow resulting from side lurches is small, owing to the fact that there is only 3/8-in. play in the axle journals. But there is another point to be considered—track irregularities and curves. In taking a curve the entire suspended weight is forced to travel sideways at a rate equal to the versed side of the angle through which the train moves in one second. This energy produces only static pressure on a true curve with all of the ties tamped equally tight and all of the spikes tight against the rail flange. The impact forces due to curvilinear deflection can be computed by the formula:

$$\frac{W\ v^2}{2\ g} = E$$

In which

E=foot lbs. energy in moving body.
W=weight of moving body in pounds.
v=velocity in feet per second.
g=gravity=32.2.

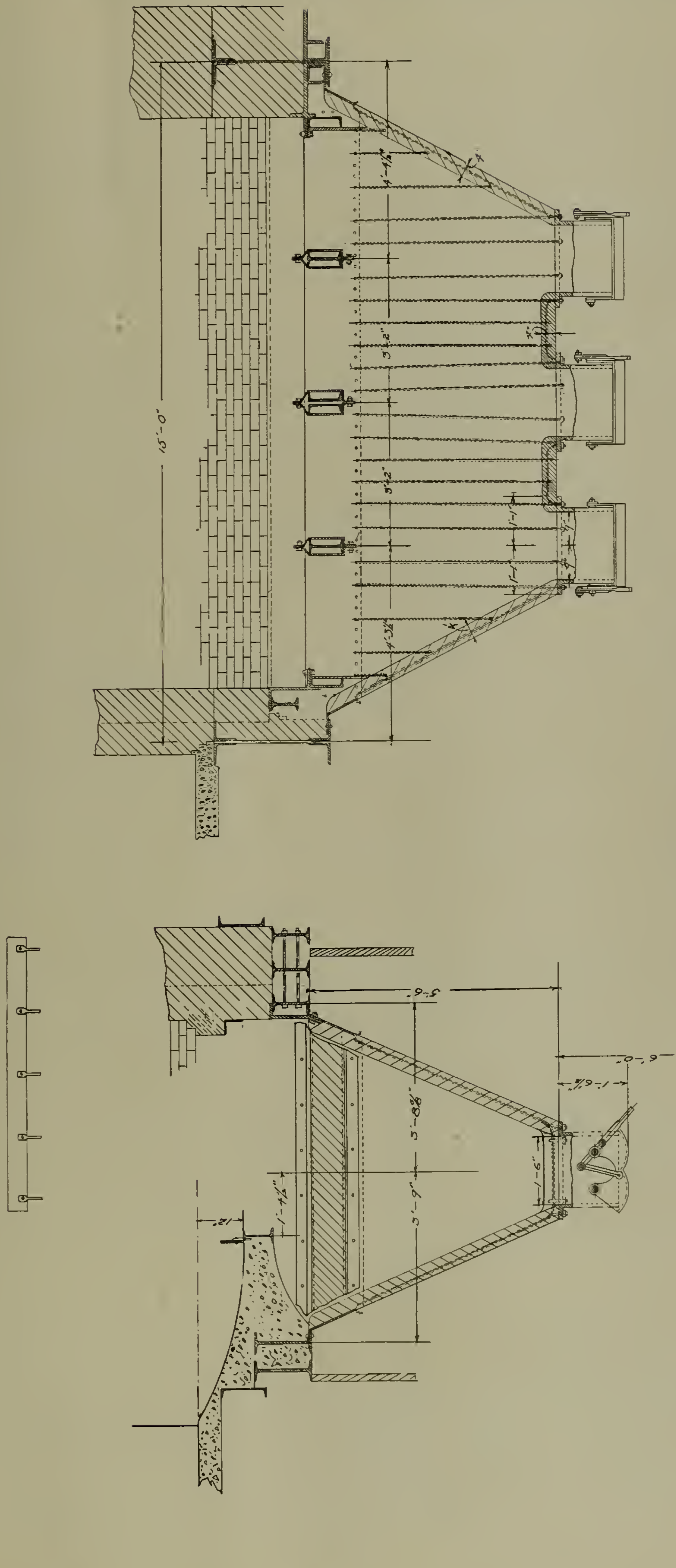
For the case in hand the weight of the moving body will be the centrifugal force due to the speed less the effect of gravity due to the superelevation. This has been computed for 3° 5′ curve with 4.5 in. superelevation.

SPRING SUSPENDED LOAD ON ELECTRIC LOCOMOTIVE DRIVERS

Speed Mi. per hr.	Versed sine in feet of distance traveled per second	Foot pounds energy due to curvilinear deflection on the curve
50	1.445	6.8
60	2.083	72.0
70	2.853	261.0
80	3.682	682.0

This energy which may come into action at any irregularity of the track equal to the versed sine given above is resisted entirely by the spikes and the friction between the rail and the tie plate. The coefficient of friction of metal on metal varies from 0.25 to 0.15. For the case in hand the friction may have been anything between 4300= lbs. increased by the unbalance centrifugal effect and that due to a thoroughly well-lubricated surface. This frictional resistance is less than the side pressure of the locomotive at a speed above 75 miles per hour at 4½″ elevation. This would bring the resultant lateral resistance on the spikes alone above a speed of 75 miles per hour. Owing to the fact that the track is elastic laterally as well as vertically it is very improbable that circumstances should arise by which the entire energy of lateral displacement was concentrated on one spike.

Track spikes, used with 100-lb. rails, are 5/8-in. square, their area in shear being 0.4 sq. in. and the bearing area of the rail against them is 0.2 sq. in. According to tests the shearing strength of steel is 8/10 of its tensile strength, or from 43,000 to 50,000 lbs. per sq. in. In the *Iron Age* of February 15, 1900, some data was given in regard to the flow of steel under pressure and the energy required to shear hot and cold steel. According to these experiments it would require from 360 to 440 ft. pounds to shear a 5/8-in. square spike. It is probable that less energy would be required after the spike had been in the track a while as the area in shear becomes reduced. From this it can be seen that the factor of safety in this piece of track supposing one spike only to act and considering the spring-suspended load only, was from 50 to 64 at 50 miles per hour, from 5 to 6 at 50 miles per hour and 1.4 to 1.7 at 70 miles per hour and 0.53 to 0.65 at 80 miles per hour on the basis that the irregularity of the track is equal to the versed sine in feet. On the other hand, if, as held by many of the most eminent railroad engineers in the country, not less than two spikes resist the shearing stresses, then we have a factor of safety at 70 miles per hour of from 2.8 to 3.4. It must also be borne in mind that this assumed speed is 24 miles per hour in excess of the speed for which the curve is elevated.



REINFORCED CONCRETE ASH HOPPER

Reinforced Concrete Ash Hopper

ONE of the novel features of the new plant of the Potomac Electric Power Co., at Washington, D. C., is the use of reinforced concrete ash hoppers beneath the boilers. The details of their construction are clearly shown in the accompanying sectional views. A convenient device in the form of a removable sifting guard is also shown.

It is well known that considerable fine coal falls through the front portion of over-feed stokers, and to prevent this being wasted a cast-iron pan is generally placed below this portion of the stoker, with a raised lip to keep the siftings in the pan. In the present case this pan is formed of concrete and the lip is made removable.

The ash hopper is a suspended structure of concrete, reinforced with ½-inch round rods, which are hooked into apron plates rivetted to the steel framing of the boiler-room floor. The cast-iron spouts for filling the ash cars are hung on these rods, those utilized for this purpose being threaded in order that the spouts may be adjusted to level. This type of hopper is much cheaper to construct than those of plate steel, which require a lining of fire-brick or concrete to prevent the steel from being rapidly eaten out by the dilute acid formed whenever the ashes are wet down. The concrete in these hoppers is no thicker than that required to line a steel hopper, and the reinforcing rods and apron plates are less than 10 per cent. of the weight of a plate hopper. To offset this reduction in the amount of steel, a wooden form is required for the reinforced concrete hopper, but when properly designed and made, such a form can be used over and over again, thus reducing to a minimum the amount of lumber required and the labor of form building.

The heat-resisting qualities of concrete, of course, depend upon the materials used in mixing, their proportions and treatment. Good Portland cement is required, clean sand of good quality, free from loam, and if broken stone or gravel is used it is important that limestones or nodules be avoided. When exposed to heat, the limestones are gradually calcined and will then slack and destroy the concrete when water reaches them, even in small quantities.

A Central Station Cable Record System

As the method of keeping track of the various circuits is of great importance to a central station, some particulars of the cable record system of the United Electric Light and Power Company, of New York, will be of interest as affording central station men an opportunity for comparison with the methods of their own company.

Each circuit of the system of the United Electric Light and Power Company is numbered. Parts of each circuit are sketched on a sheet of heavy paper, each sheet being given a map number and carrying also the number of the circuit. Thus, Fig. 1 represents part of circuit No. 106. Primary cables are shown by full blue lines (shown as broken lines in the diagram), and secondary cables by full red lines (shown dotted in the diagram). Manholes are represented by circles, and service boxes by squares. When cables extend further than can well be shown on one map, a new map number is placed at the point at which the cables end on that particular sheet, and by referring to the new map, the further extension of the cables can be found.

Thus, in Fig. 1 at the lower right-hand corner, the limits of the sheet prevent the path of the primary cables being followed further, so that map No. 1 must be consulted. Similarly, the rest of the secondary cables shown in the lower left-hand corner may be found by reference to map No. 11, the continuation of the primaries at the middle right will be given on map No. 4, while the primaries and secondaries at the top of the diagram are contained on map No. 5.

Each section of both primary and secondary cable is lettered, as shown in the middle of the diagram. But one example is taken as being typical of the whole system. The meaning of the figures and letters is as follows:

Three Washburn & Moen cables, rubber insulation, 5/32-inch thick, curb duct, three Roebling cables, paper insulation, 7/32-inch thick, curb duct. The meaning of "curb duct" will be clear by referring to the diagram in the lower right-hand corner of Fig. 2. The ducts are laid as shown and are numbered beginning at the curb, the first duct being known as the curb duct, and so on. If the primary cables in Fig. 1 were run in No. 2 duct, the letters "C D" would be replaced by "No. 2 D."

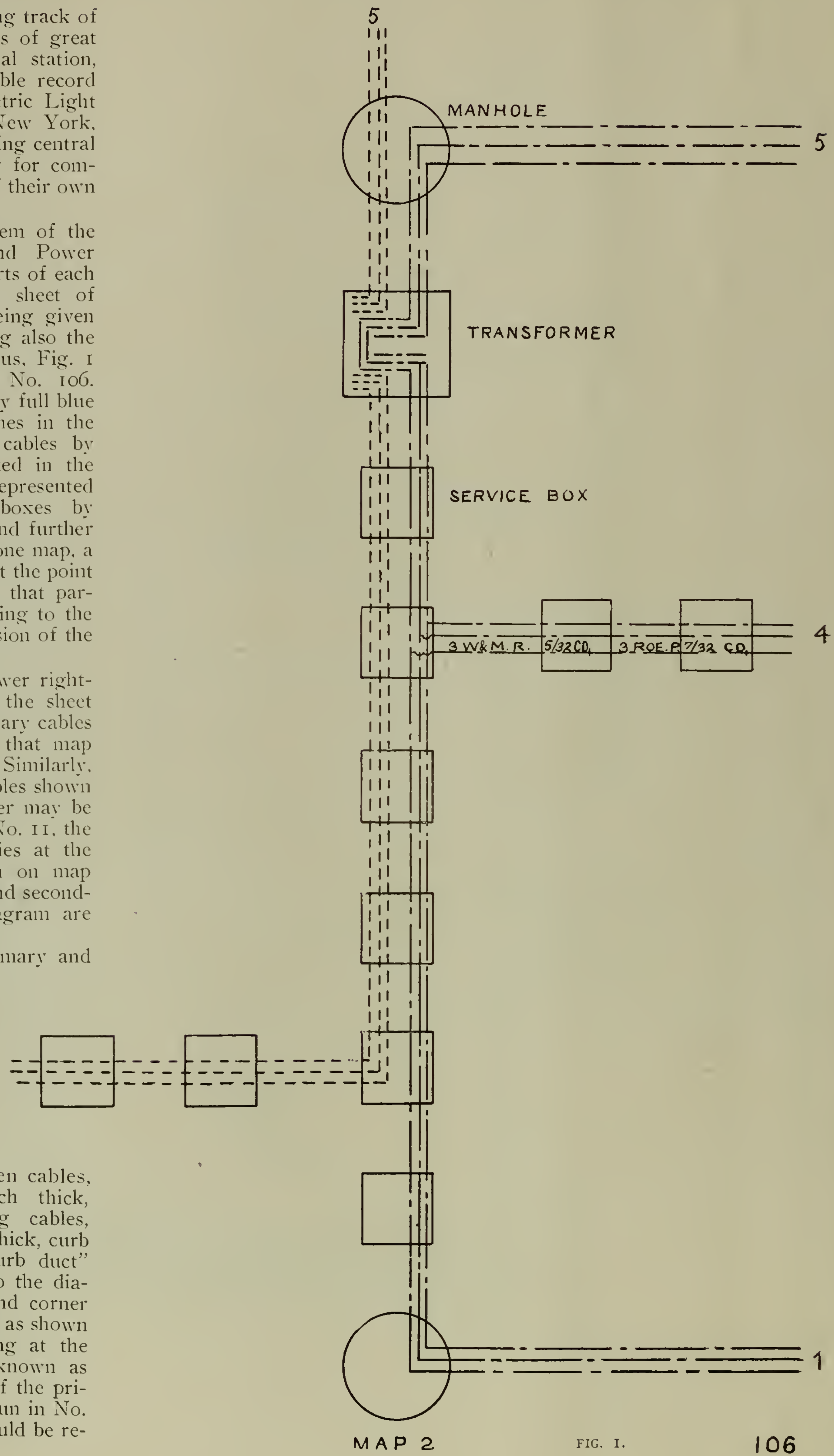


FIG. 1.

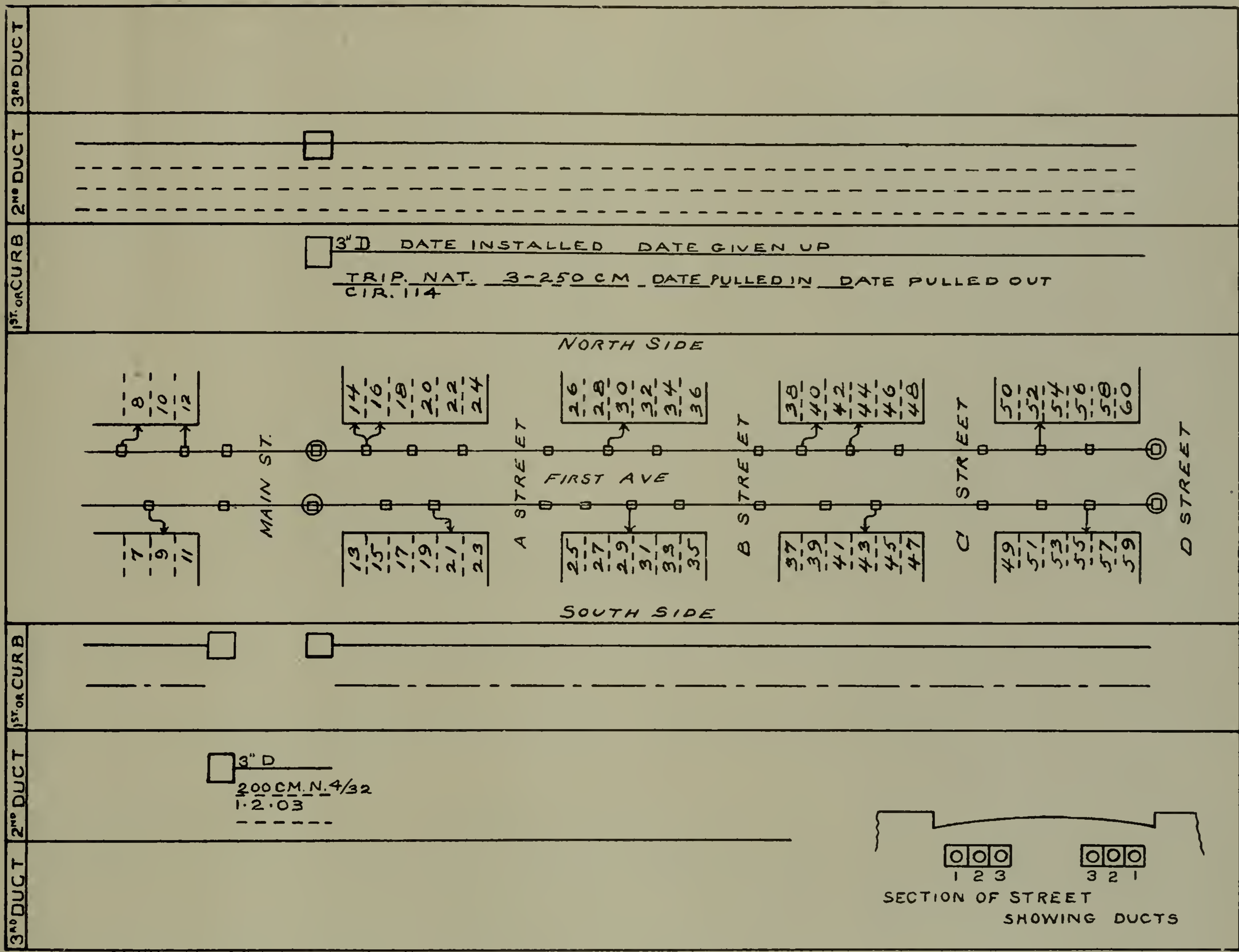


FIG. 2.

In Fig. 2 is shown the chart by which more detailed data regarding the cables and the service may be obtained. Along the middle of the sheet is outlined each avenue with its cross streets, the buildings and their street numbers. Two red lines are drawn in to show that service is available, manholes being represented by circles and service boxes by squares. The subsidiary connections, as they are called, which consist of the cables from the service box to the customer's premises are shown by arrows, also in red ink.

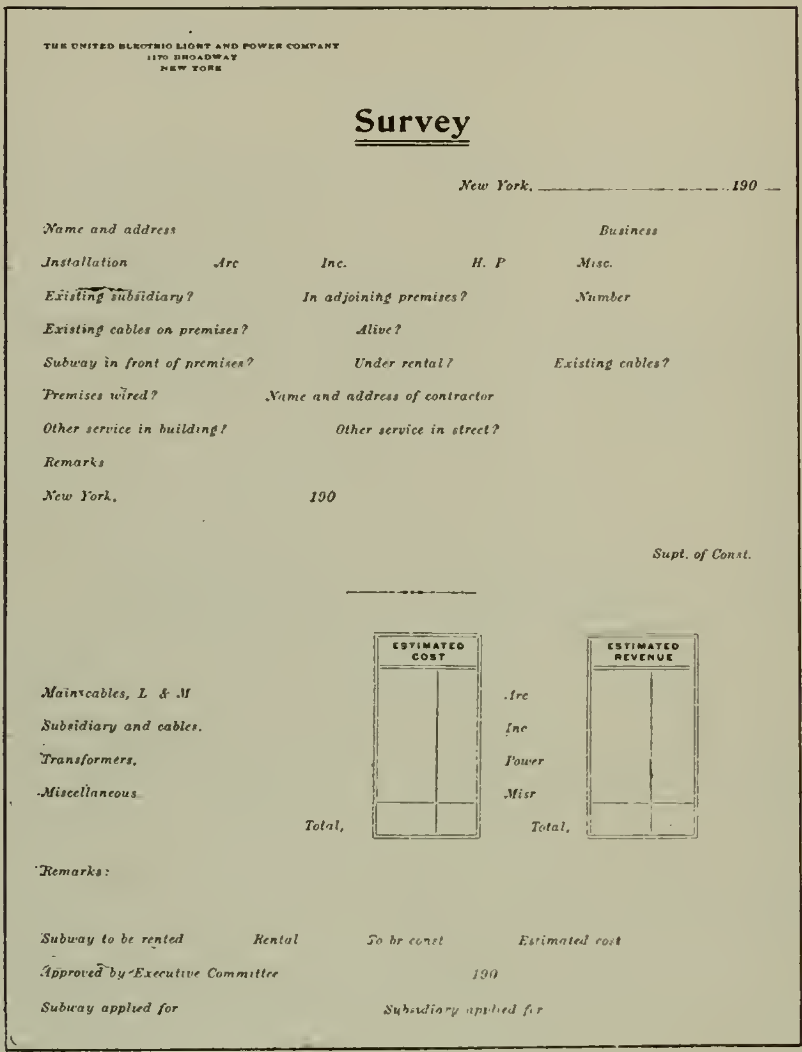
On each side of the street are ruled off spaces equal in number to the number of ducts on each side. Thus, as on this street three ducts are laid on each side, three spaces are ruled off and labeled as indicated, "1st or curb," "2d duct" and "3d duct." In each section is first indicated by a black line the extent of that duct, and below it is shown in blue if a primary cable, and in red if a secondary, the extent of the cable in that duct. The size of the duct, the date installed, and the date given up are placed above the line. Above the line representing the cable are placed the size and style of the cable, and date pulled in, the date pulled out, and below it the circuit number.

To illustrate: On the north side of the street the curb duct extends from the corner of Main street to D street. The primary cable in that duct, however, extends only as far as the middle of the block between B street and C street. The size of the duct is 3 inches. The cable is a triplex "National," consisting of three 250 circular mil leads. The circuit number is as indicated, 114.

Location ____________________

CUSTOMER	Length and Diameter of Subsidiary	Date Applied For	Date Completed	Cost	Owner	Cir. No.	Primary Kind	Primary Size	Primary Length	Secondary Kind	Secondary Size	Secondary Length	Date Pulled In	Date Connected	Date Test Capped	Date Cut Dead	Date Pulled Out	A. B. Number	REMARKS

FIG. 3.



THE UNITED ELECTRIC LIGHT AND POWER COMPANY
1170 BROADWAY
NEW YORK

Survey

New York, ...190 ..

Name and address Business

Installation Arc Inc. H. P Misc.

Existing subsidiary? In adjoining premises? Number

Existing cables on premises? Alive?

Subway in front of premises? Under rental? Existing cables?

Premises wired? Name and address of contractor

Other service in building? Other service in street?

Remarks

New York, 190

Supt. of Const.

	ESTIMATED COST		ESTIMATED REVENUE
Main cables, L & M		Arc	
Subsidiary and cables.		Inc	
Transformers.		Power	
Miscellaneous		Misc	
Total,		Total,	

Remarks:

Subway to be rented Rental To be const Estimated cost

Approved by Executive Committee 190

Subway applied for Subsidiary applied for

FIG. 4, A.

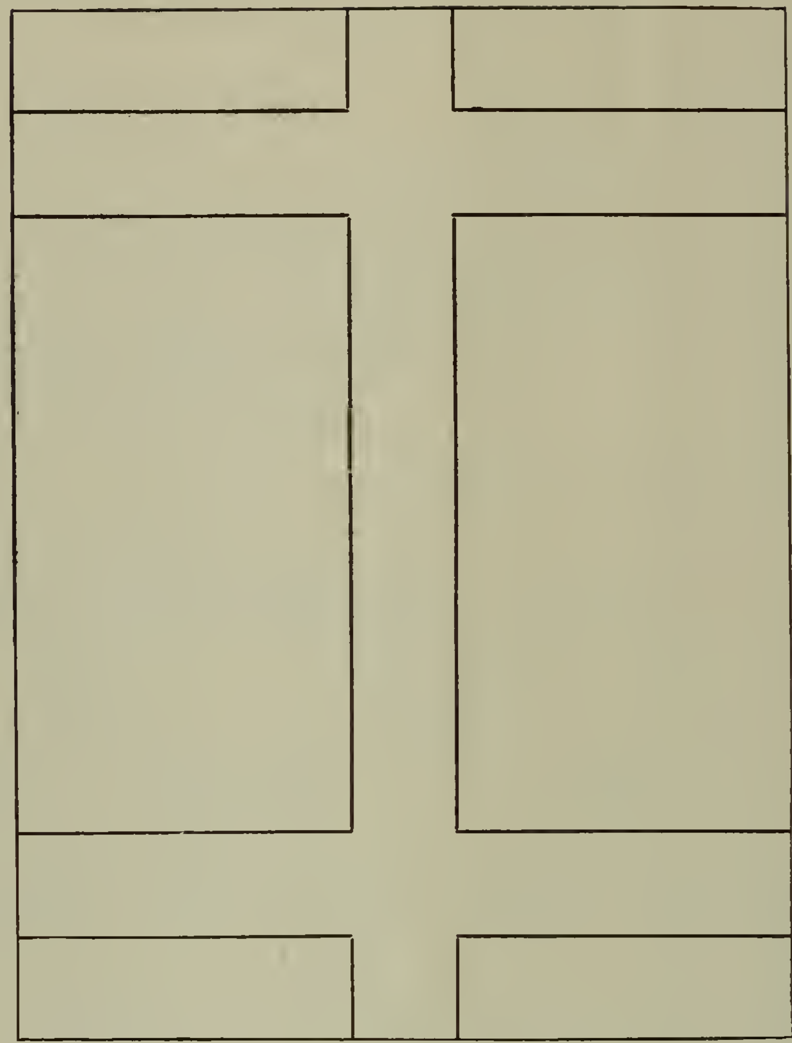


FIG. 4, B.

In the second duct on the north side, a secondary cable extends the full length of the duct. This cable comes from the secondary of a transformer in building No. 44, the primary running as shown, in the curb duct. Transformers are not indicated on the service chart, however, that detail being given only on the map of the circuits as in Fig. 2, which shows a transformer from which secondary circuits extend both ways. In this case the primary circuit does not stop at the building, but continues on. These transformers are installed in buildings where current is supplied.

Wherever a lamp on a street corner is supplied, the secondary will appear somewhat as in the section showing No. 2 duct on the south side of the street. It apparently has no connection with any primary or secondary, but by referring to the chart of Main street, its connection with the circuit can be found. It will thus be seen that the whole system can be followed up from street to street, and the path of the current from the power-house to the customer's premises quickly traced by means of the maps and the service charts.

When a customer applies for the company's service, a survey is made by the construction department, a report being made on the blank form shown at A, Fig. 4 and a sketch B is made on the back of the report as to the way in which the subsidiary connection is to be installed. In making this survey, the circuit maps and charts are referred to in order to find the location of the nearest cables and service boxes. An estimate of the cost of, and revenue from, the installation is then made. On a form shown in Fig. 5 the electrical engineer gives type of service and style of cables to be used.

If the proposed installation is approved, a card, shown in Fig. 3, is filled out and filed according to the location of the customer's building. The various headings clearly indicate the data given on the card, so that no explanation is necessary, except, perhaps, as to that of owner, and "A B Number."

When a customer complains of trouble with his service, this card is looked up under the street and the number of the circuit obtained. The location of the circuit is then obtained from the chart and map, and the trouble remedied.

FORM 63. 9-20-06-500 11415

The United Electric Light & Power Co.

1170 BROADWAY

Name ____________________

Location ____________________

Description ____________________

____

Architect ____________________

Contractor ____________________

Owner ____________________

(Names and Addresses)

EQUIPMENT

LIGHTING						POWER
8 C. P.	16 C. P.	32 C. P.	Arc			Size and Character of Work of Each Unit

Total 16 C. P. Lighting ____________ Aggregate Power ____________

Remarks ____________________

____

Character of Service to be Introduced ____________________

____

Approved ____________________
Electrical Engineer

____
Agent

FIG. 5.

Methods of Solving Ice Problems In Water Power Plants

BY R. C. BEARDSLEY.

Our article in last month's issue on "The Ice Problem on Open-Ditch Water-Power Canals," by A. W. Dawson, has induced Mr. Beardsley, Chief Engineer in the Hydraulic Department of the Roberts & Abbott Co., of Cleveland, Ohio, to relate some of his experiences in the solution of such problems.—The Editor.

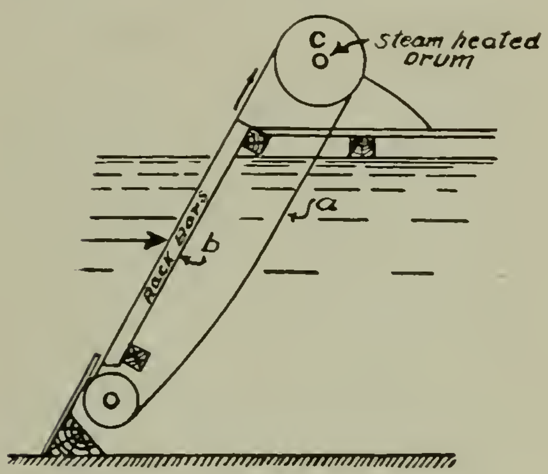
Anchor ice in nearly every case forms on rapids above a dam, and very seldom, if ever, forms in deep channels. Anchor ice, having once formed, is slightly heavier than water and floats along at all depths, depending upon the temperature of the water. Frequently this anchor ice sinks to the bed of the river and forms to a considerable depth, sometimes even raising the level of the water; at other times it comes to the surface and floats along in large masses resembling clouds in appearance. It is, therefore, absolutely impossible to provide any means above the intake for keeping this anchor ice out of the canal.

The concrete apron suggested by Mr. Dawson in his article in the February number of The Electrical Age has been used (though usually made of timbers) for many years to keep floating trash out of a canal, but as will readily be understood, such a device would afford no security against anchor ice. There is only one sure way of eliminating anchor ice troubles, and that is to build the rack with the especial object in view of disposing of the troublesome material.

This may be accomplished, as shown in the annexed illustration, by the use of a rack made in 6-foot sections. The rack bars may be made of steel, reinforced concrete, or timber, and serve merely as slides for the netting, *a*, which passes over the drum *c*. This drum should be heated in some way, preferably by steam where it may be obtained, although the heating may be done with a stove. The speed of the drum should be such that all the ice drops off on the down stream side as the netting passes over the drum. The entire rack should be enclosed in some structure so that it may be heated. This method, while costing slightly more than the ordinary racks, is absolutely sure.

In one instance here a large pulp mill, using about 3000 horse-power, had been compelled to shut down for days at a time during the periods of anchor ice flow; the difficulty was overcome by merely building a house over the racks and keep it warm. In this case, however, it required the services of three to five men constantly to rake the anchor ice off the racks.

Mr. Dawson makes one statement in his article, previously mentioned, which seems to me should be questioned, as it reflects upon the general ability of our hydraulic engineers. He states that the water powers of this country are usually designed to have a water velocity of from 2 to 4 feet per second. This is certainly misleading as a general statement. In a large majority of cases we design a water power to have a velocity of from 90 to 100 feet per minute at the racks and 100 to 150 feet per minute in the tail race. This velocity should not be exceeded, except in a few special cases, where cost is prohibitive. If high velocities are secured at the head racks, the condition of affairs indicated in Fig. 7 of Mr. Dawson's article is sure to take place, no matter whether the clogging element is ice, driftwood, leaves or grass, while if the area is liberal, excessive clogging cannot take place before the rack cleaners have time to clean the racks.



Although troubles are frequent with the head rack, there are many more troubles with the tail water. It is a very common condition to find that in winter, owing to the tail race becoming clogged with thick ice, the tail water is backed up several feet. The tail race being frozen so that its area is diminished, the water discharged from the turbine backs up and runs over the top of the ice, and freezing, backs the water still higher. This process keeps on from day to day. Aside from the actual cleaning of the ice out of the tail race there is only one way to prevent this loss of head, and that is by building the tail race so deep that the 3 or 4 feet of ice which is apt to form in winter, still leaves sufficient area beneath to carry off the water. If this depth cannot be obtained, the tail race must be covered over.

Another very serious winter nuisance is the formation of thick ice on the head race. The formation of ice on the canal not only reduces the area of the canal by about three-fourths the thickness of the ice, but also greatly increases the wetted perimeter. The under surface of the ice is quite rough, and being in contact with the flowing water, affords a certain amount of resistance.

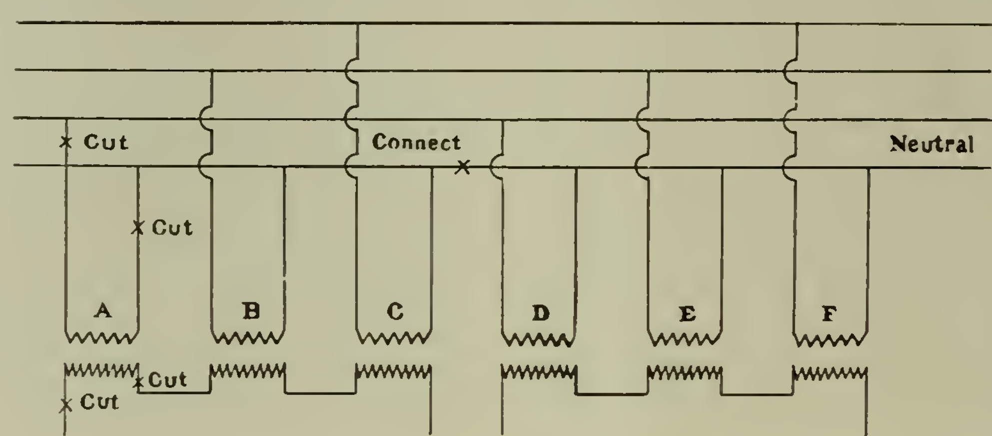
Anchor ice cannot be permitted to pass through the turbine, as no matter how great the velocity or what the shape of the orifice may be, the anchor ice will rapidly close the opening. If the flow of anchor ice is considerable, a large turbine will be completely smothered inside of a few minutes.

The Effect of the Removal of One Transformer from a Set of Three Connected in Star or Delta

BY C. J. SPENCER.

When one transformer of a bank of three connected in delta becomes disabled, the remaining two transformers will supply a balanced load amounting to two-thirds normal rated load. This fact has led to various connections of the remaining two of a bank of three transformers connected in star or Y, when one transformer is removed, to obtain an output proportional to the transformer capacity as in the delta connection.

With a bank of three transformers connected in Y, the cutting out of one transformer by short-circuiting the primary connections causes a voltage of 73 per cent. above normal to be impressed on the remaining two. Some transformers, notably those with extremely low iron losses, will stand this treatment and give somewhere near normal secondary voltage, but this is very rare. The iron loss increases rapidly with an increase of im-



pressed voltage, and the ordinary transformer has an excessive rise of temperature when the voltage is increased 25 per cent. above normal. The result to be expected is that the iron loss will be so very much above normal that the insulation will burn out, and this does occur.

One connection that has been suggested is to join the remaining two transformers in T. This is done by connecting one end of the one transformer primary to the neutral of the second transformer primary. This does not improve matters to a great extent, as the impressed voltage on one transformer is 73 per cent. above normal, and that on the other is 50 per cent. above normal. The result with either connection is the destruction of one, or, perhaps, both of the transformers.

Two sets of three transformers connected in Y and having a common neutral, as in the accompanying diagram, can be made to supply a load, though the capacity is only equal to that of one set alone. The elimination of one transformer from the circuit throws a double load on the transformer that supplies that phase, and its primary may be loaded to full capacity.

Connections of secondaries may be made delta or Y, regardless of the primary connections. With secondaries in Y, the elimination of one transformer practically puts the set out of service, for the voltage obtained by the two secondaries in V is only 58 per cent. of normal and this is too low for operating motors or lamps.

Secondaries connected in delta are operative with two in V at two-thirds the capacity of the three transformers. The voltage is normal, but the current drawn from each secondary at normal load amounts to 50 per cent. over normal, regardless of primary connections.

The nature of the load also affects the distribution of current. Induction motors tend to balance the load, whether the line be delta or Y connected. The motor draws energy from phases of higher voltage and supplies the low-voltage phase, tending to maintain a balanced voltage.

This feature of a power load has been applied to advantage in stations when the lighting load is comparatively small by throwing the entire lighting load on one phase and regulating the voltage of this phase alone. In the same way induction motors may be utilized to tide over times of trouble by keeping them in operation when one transformer of a set becomes disabled.

Electric Motor Connections

NORMAN G. MEADE

THE diagrams of motor connections in this article have been secured from the representative electric companies of the United States and cover both direct current motors—series, shunt and compound wound—and alternating current motors—single phase and induction motors, both two and three phase. The same class of machines manufactured by the various companies are grouped and the connections shown under the general heads, direct current motors and alternating current motors. The direct current motors are subdivided into series wound, shunt wound and compound wound. The alternating motors are subdivided into single phase and induction motors both two and three phase.

In the installation of electric motors there are a number of considerations that must be borne in mind, beside the accuracy of the connections, which may be summed up in a few general suggestions as follows: All conductors, however well insulated, should always be treated as bare, that is, under no conditions, existing or likely to exist, must a ground or short circuit occur, and all leakage from one conductor to the other or from conductor to ground must be reduced to a minimum.

In all wiring, special attention must be paid to the mechanical execution of the work. Careful, and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings are especially desirable. All wiring should be thoroughly protected from mechanical injury or abrasion and a strict compliance with the rules of the National Board of Fire Underwriters should be adhered to.

So far as possible, motors should be placed in clean, dry, well-lighted and well-ventilated locations. They should be preferably raised from the floor and secured firmly to a solid foundation, a rigid floor, wall or ceiling where they will be free from vibration.

The accompanying diagrams are self-explanatory, and by tracing the connections carefully the reader should be enabled to install motors of all classes.

DIRECT-CURRENT MOTORS—SERIES WOUND.

Follow diagram very carefully when connecting up the motor and resistance to controller. Run line wires to the fused switch. See that the controller handle is in the off position. Close the line switch. Then with no load on the motor turn controller to first notch. If the motor fails to start, try second notch for a very short time, then if it does not start, turn off controller and examine all connections.

When the connections are correctly made the motor will give one rotation with forward movement of the controller, and opposite rotation with reverse movement of controller. If the rotation of armature is opposite to that desired, interchange the armature wires A and AA in the controller. This applies to Figs. 2 to 8, inclusive, when controllers are used.

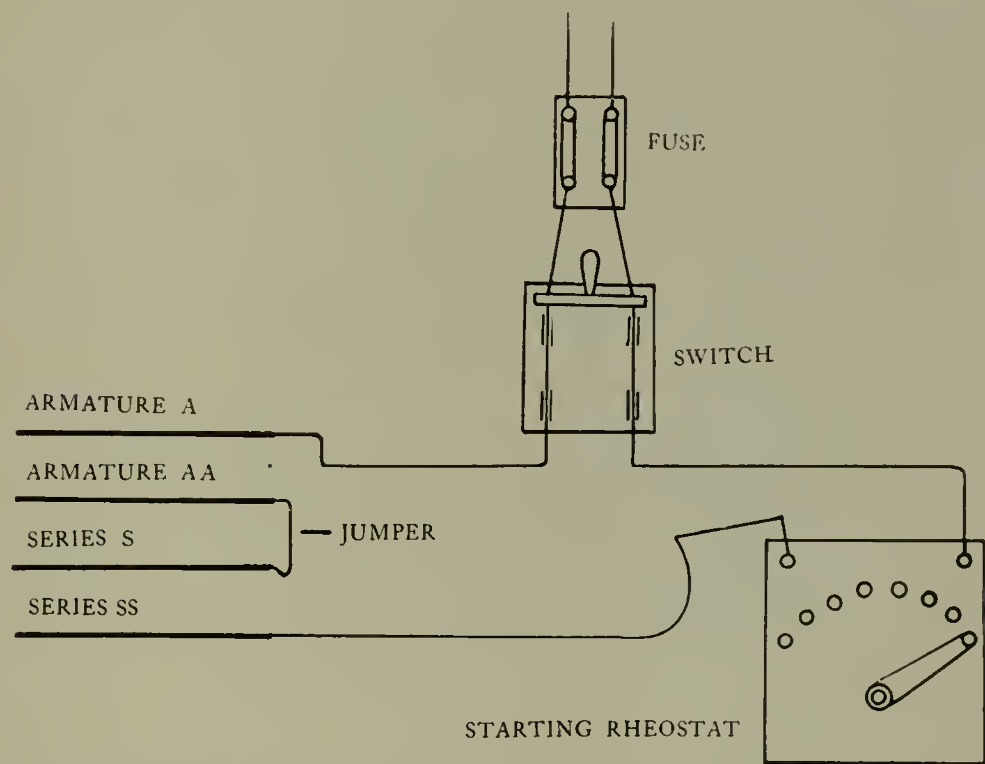


FIG. 1.—DIAGRAM SHOWING HOW THE MOTOR MAY BE CONNECTED UP FOR USE WITH AN ORDINARY STARTING RHEOSTAT. THIS APPLIES TO ANY SERIES MOTOR.

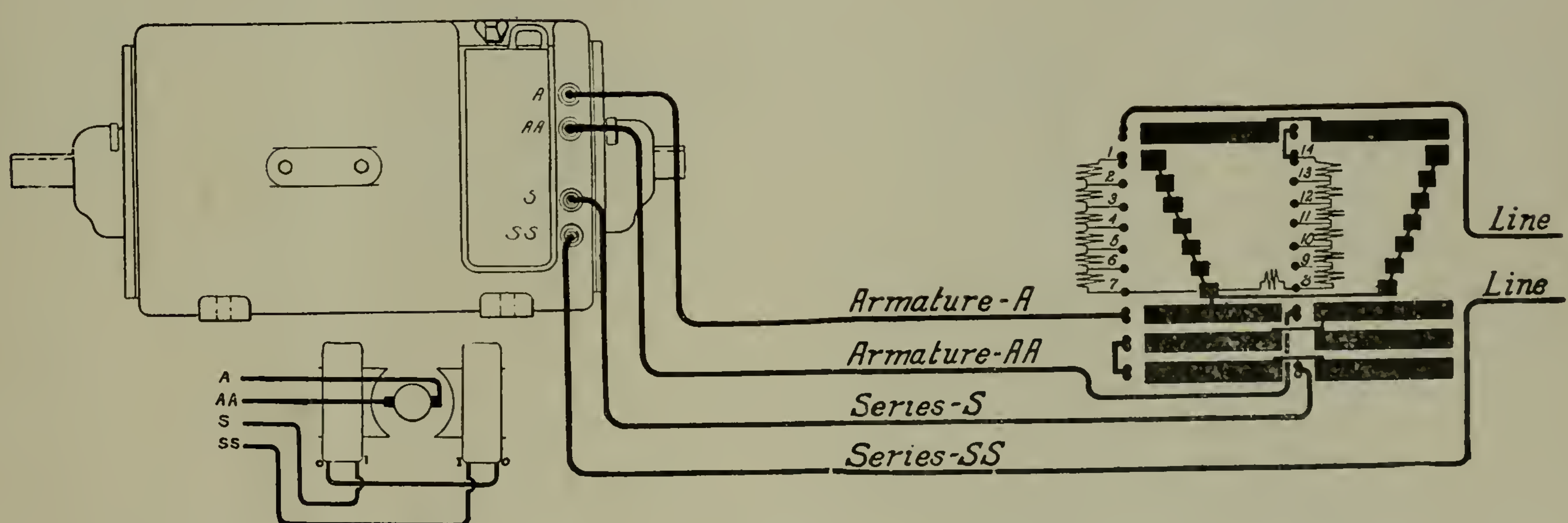


FIG. 2.—SIZE 2½K AND 6K SERIES MOTOR WITH CONTROLLER. FIELDS IN SERIES. CROCKER-WHEELER COMPANY.

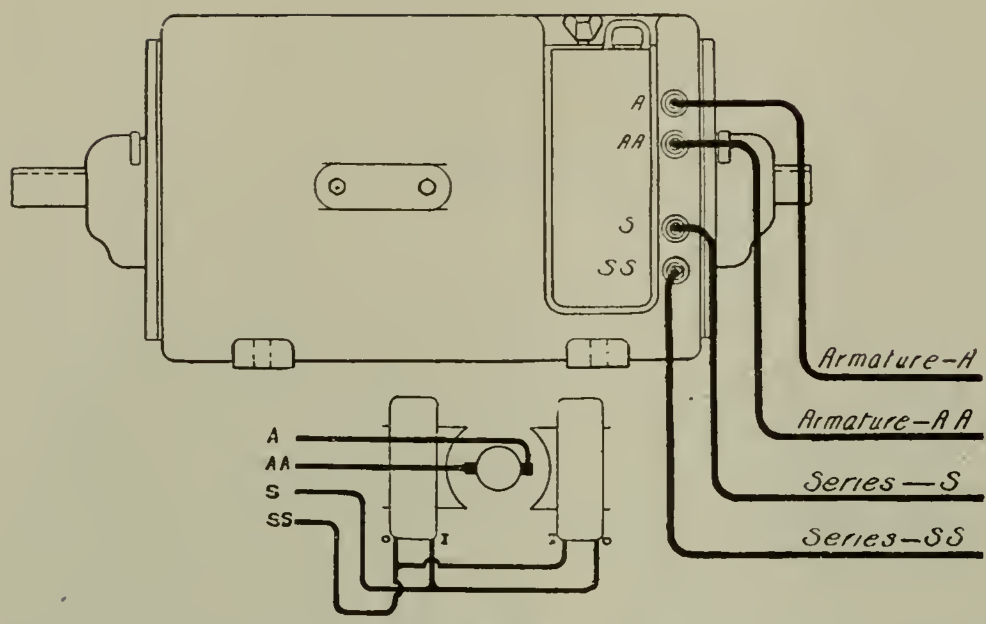


FIG. 3.—SIZE 2½K AND 6K SERIES MOTOR. FIELDS IN PARALLEL. CROCKER-WHEELER COMPANY.

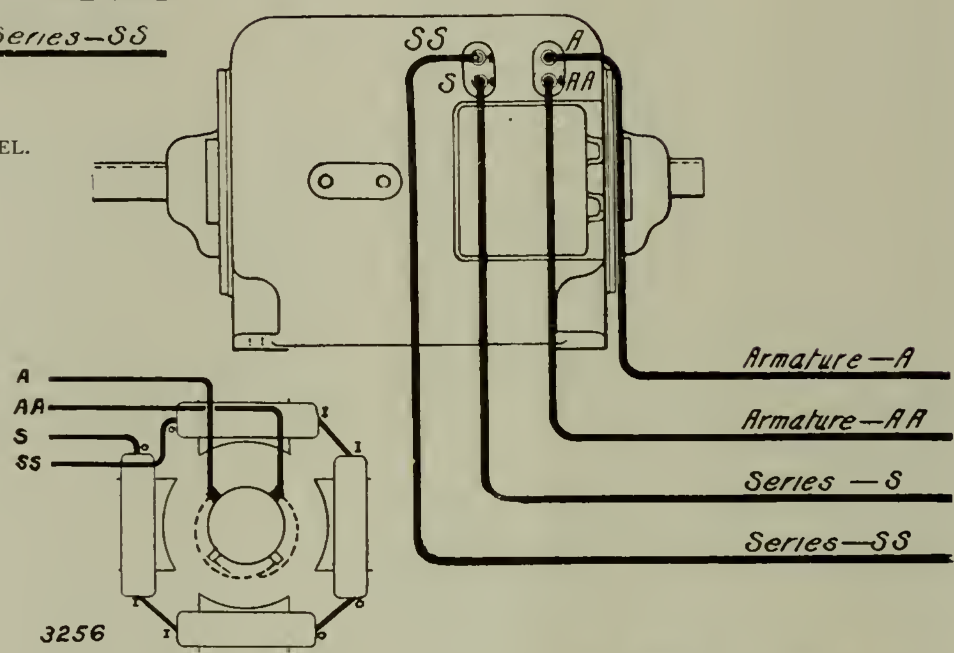


FIG. 6.—SIZE 20K, 30K AND 45K SERIES MOTOR. FIELDS IN SERIES. CROCKER-WHEELER COMPANY.

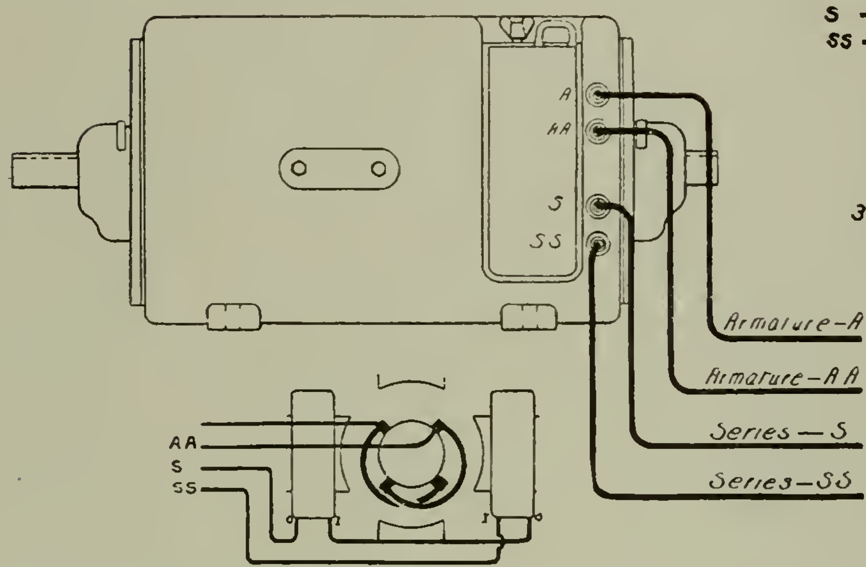


FIG. 4.—SIZE 12K SERIES MOTOR. FIELDS IN SERIES. CROCKER-WHEELER COMPANY.

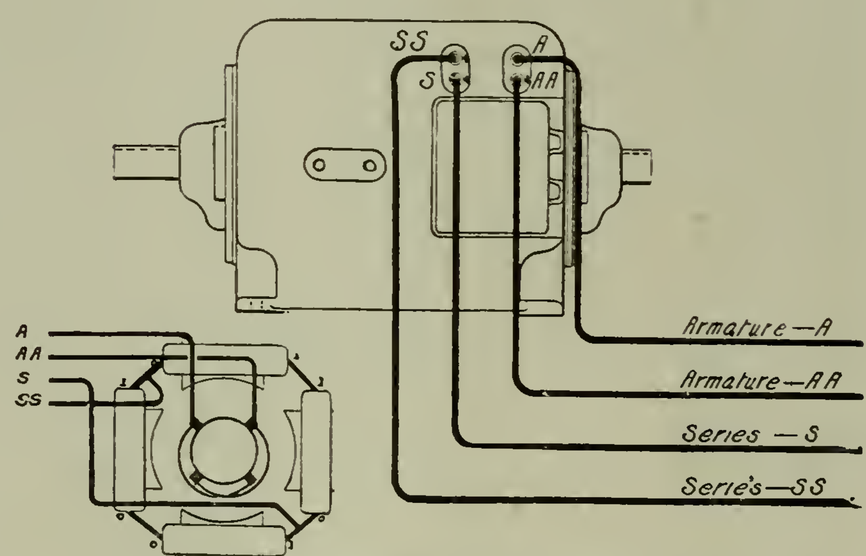


FIG. 7.—SIZE 20K, 30K AND 45K SERIES MOTOR. FIELDS IN SERIES-PARALLEL.

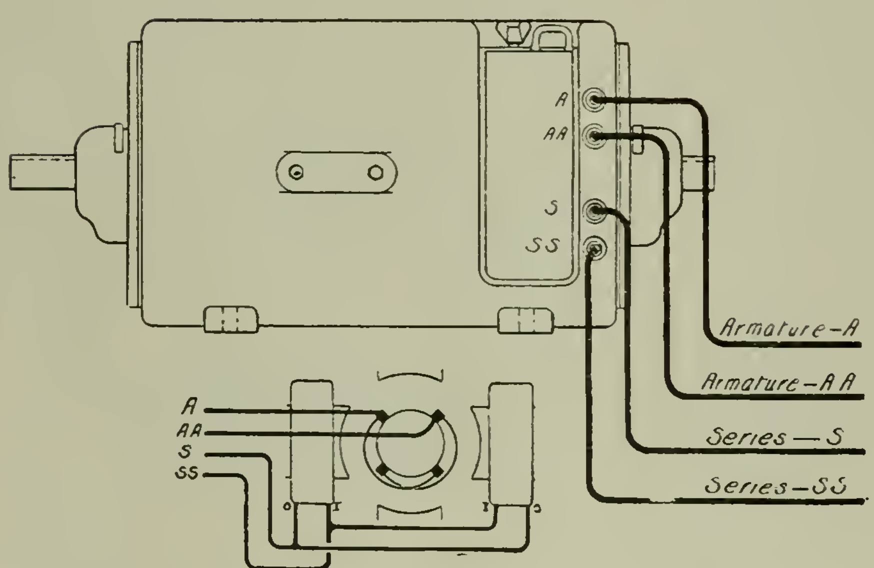


FIG. 5.—SIZE 12K SERIES MOTOR. FIELDS IN PARALLEL. CROCKER-WHEELER COMPANY.

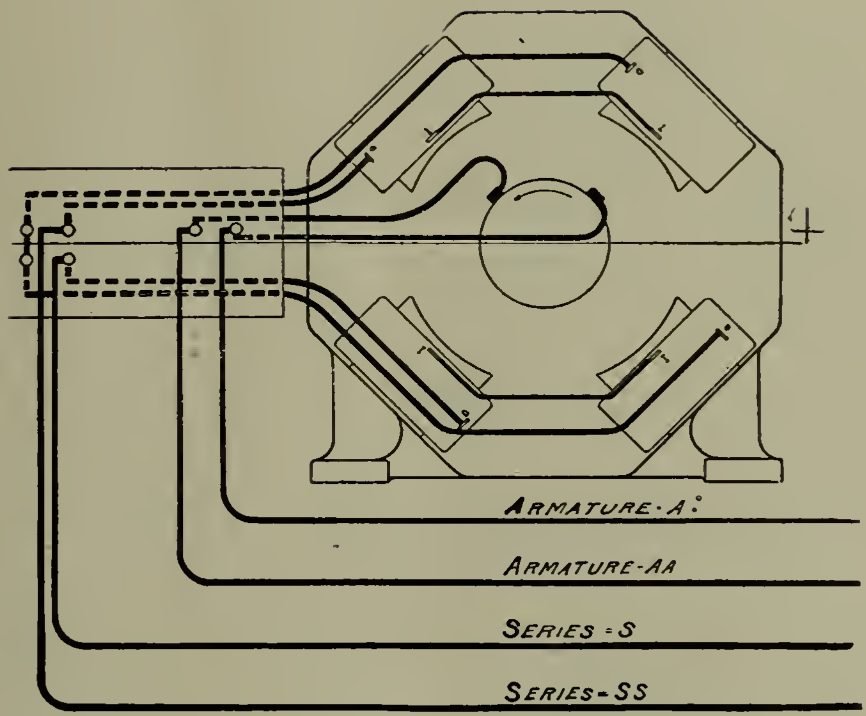


FIG. 8.—SIZE 25W AND 50W SERIES MOTOR. CROCKER-WHEELER COMPANY.

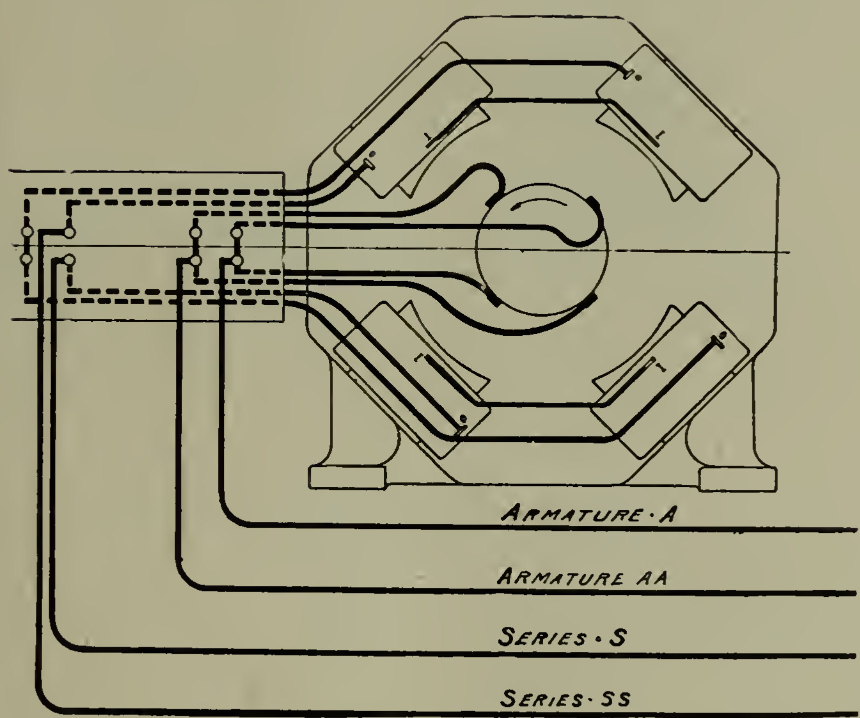


FIG. 9.—SIZE 75W AND 100W SERIES MOTOR. CROCKER-WHEELER COMPANY.

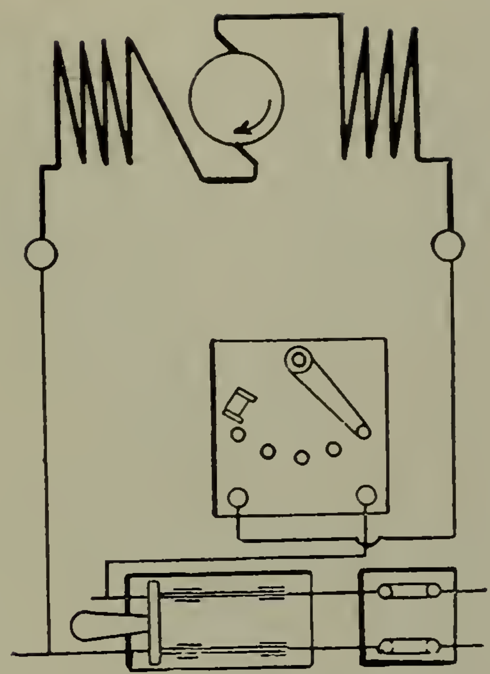


FIG. 10.—TWO POLE SERIES MOTOR. ROBBINS-MEYERS COMPANY.

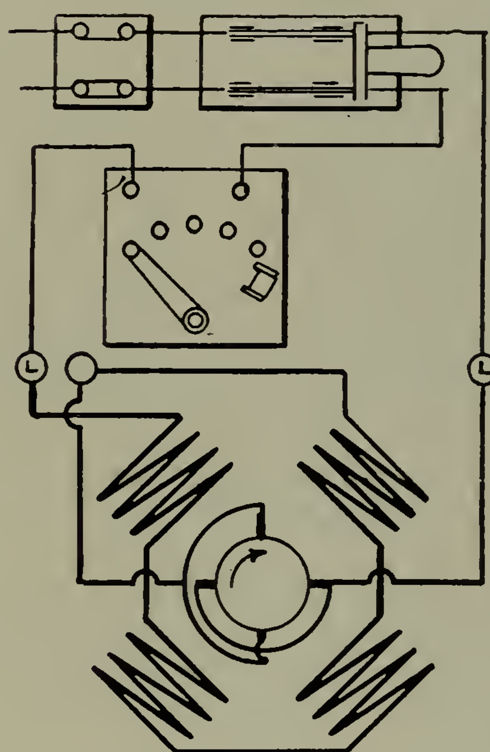


FIG. 11.—FOUR POLE SERIES MOTOR. ROBBINS-MEYERS COMPANY.

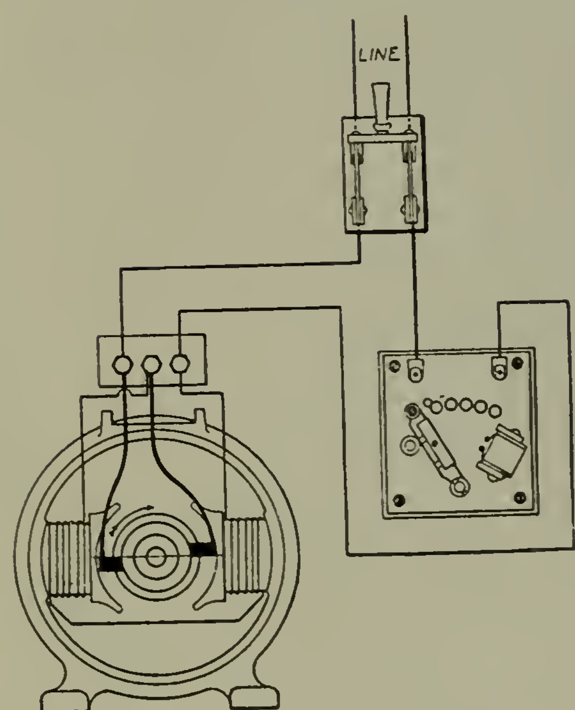


FIG. 12.—ONE-SIXTH TO 3 H. P. TYPE E SERIES MOTOR. HOLTZER-CABOT COMPANY.

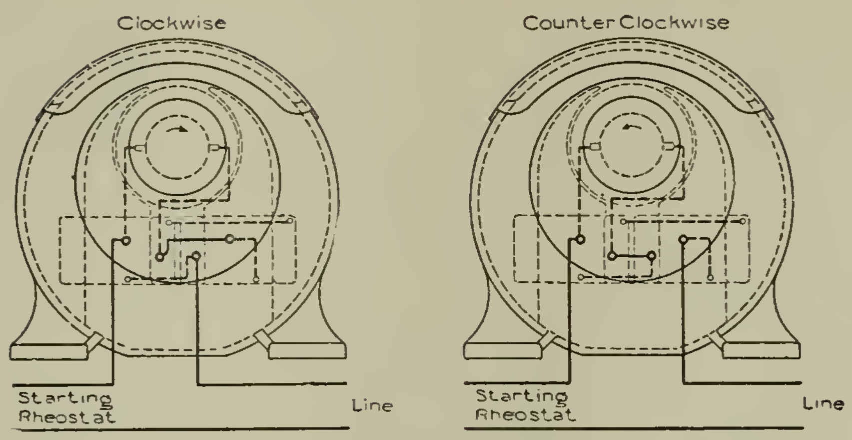


FIG. 13.—FORM B SERIES WOUND CA MOTOR. GENERAL ELECTRIC COMPANY.

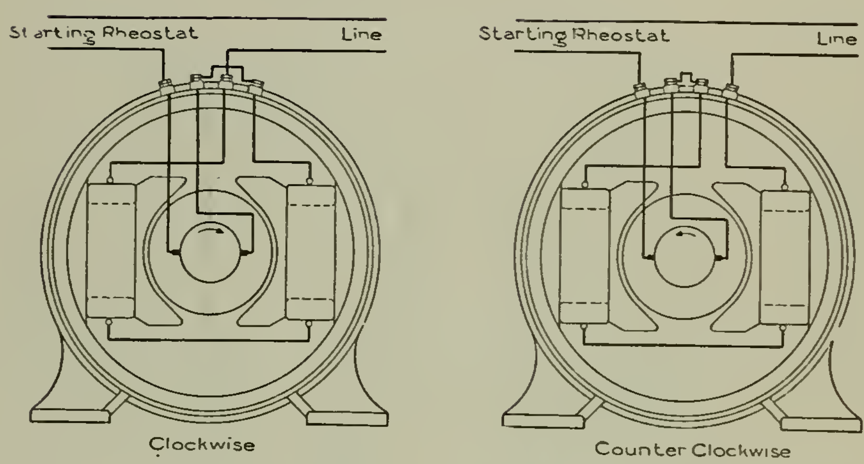
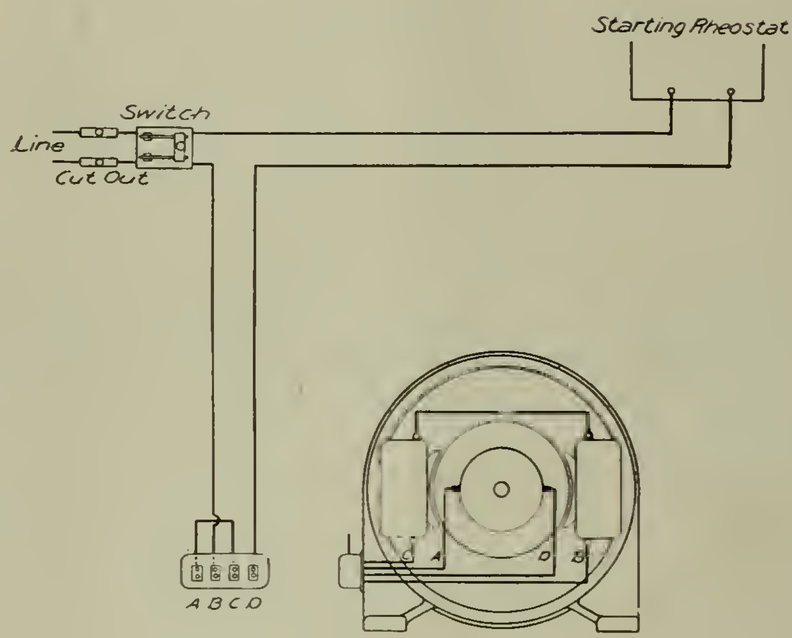


FIG. 14.—SERIES WOUND CE BIPOLAR MOTOR. GENERAL ELECTRIC COMPANY.

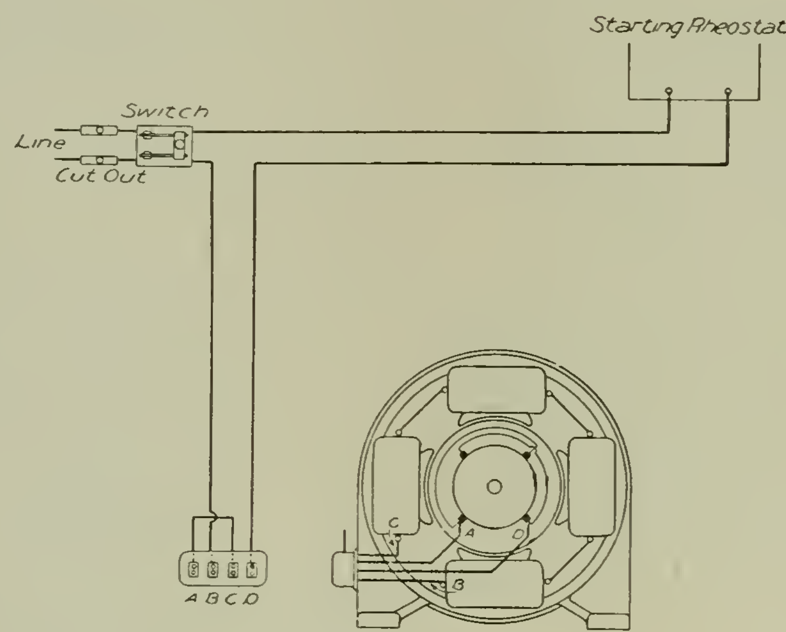
An arrow and the letter "I" or "O" are cast on each of the terminals of the field coils. The coils should be so assembled on the poles that the arrow will point toward the armature and the like letters will be adjacent for connection together.

On grounded circuits it is recommended that the rheostat be connected to the positive or line side and the series field to the negative or ground side.



A and D are Armature Terminals.
B and C are Field Terminals
Motor Connected for Counter Clockwise Rotation For Clockwise Rotation change external connection from B to C and connect A to B at the Terminal Block.

FIG. 15.—SERIES WOUND CQ BIPOLAR MOTOR. GENERAL ELECTRIC COMPANY.



A and D are Armature Terminals
B and C are Field Terminals
Motor Connected for Counter Clockwise Rotation. For Clockwise Rotation change external connection from B to C and connect A to B at the Terminal Block

FIG. 16.—SERIES WOUND CQ FOUR POLE MOTOR. GENERAL ELECTRIC COMPANY.

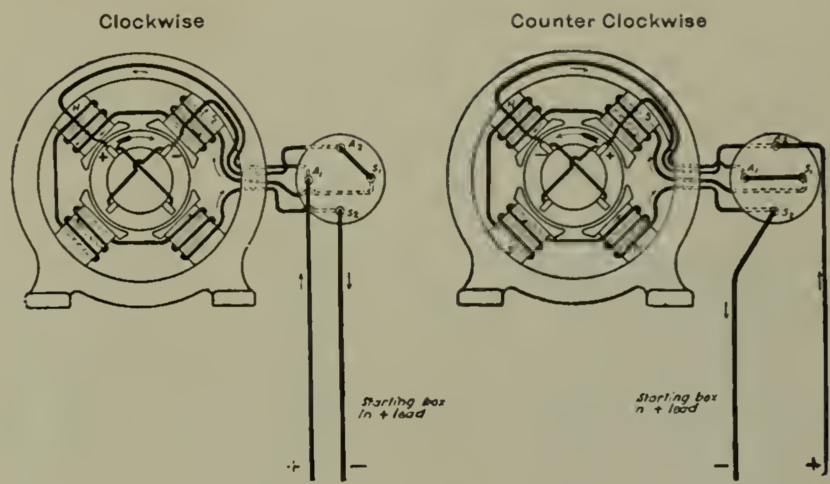


FIG. 18.—SERIES WOUND TYPE S MOTOR, FRAMES 1 TO 6, INCLUSIVE. TWO OR FOUR BRUSH ARMS, VIEWED FROM COMMUTATOR END. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

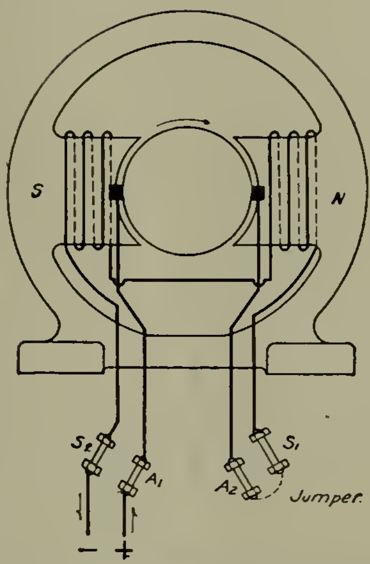


FIG. 17.—SERIES WOUND TYPE R MOTOR, VIEWED FROM COMMUTATOR END. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

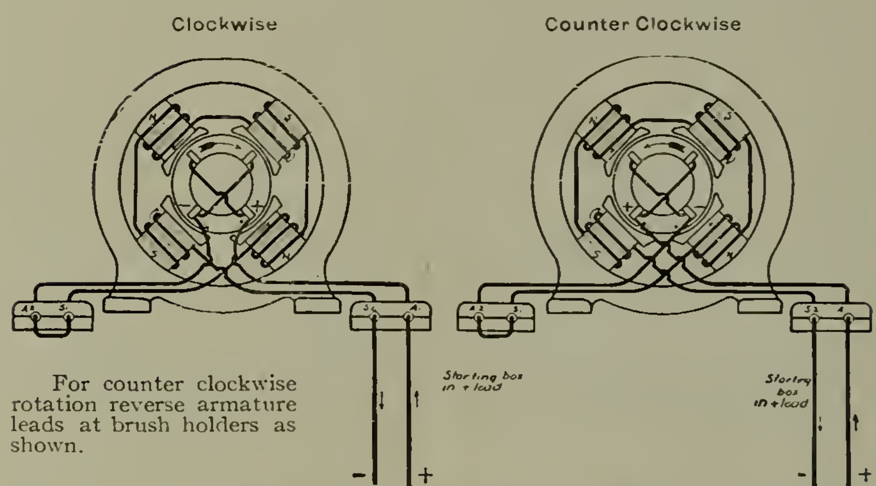


FIG. 19.—SERIES WOUND TYPE S MOTOR, FRAMES 7 TO 13, INCLUSIVE. FOUR BRUSH ARMS, VIEWED FROM COMMUTATOR END. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

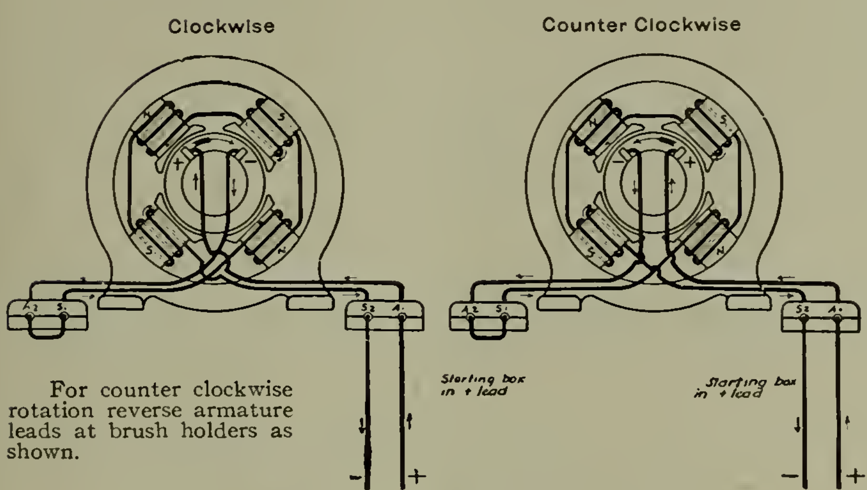


FIG. 20.—SERIES WOUND TYPE S MOTOR, FRAMES 7 TO 13, INCLUSIVE. TWO BRUSH ARMS, VIEWED FROM COMMUTATOR END. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

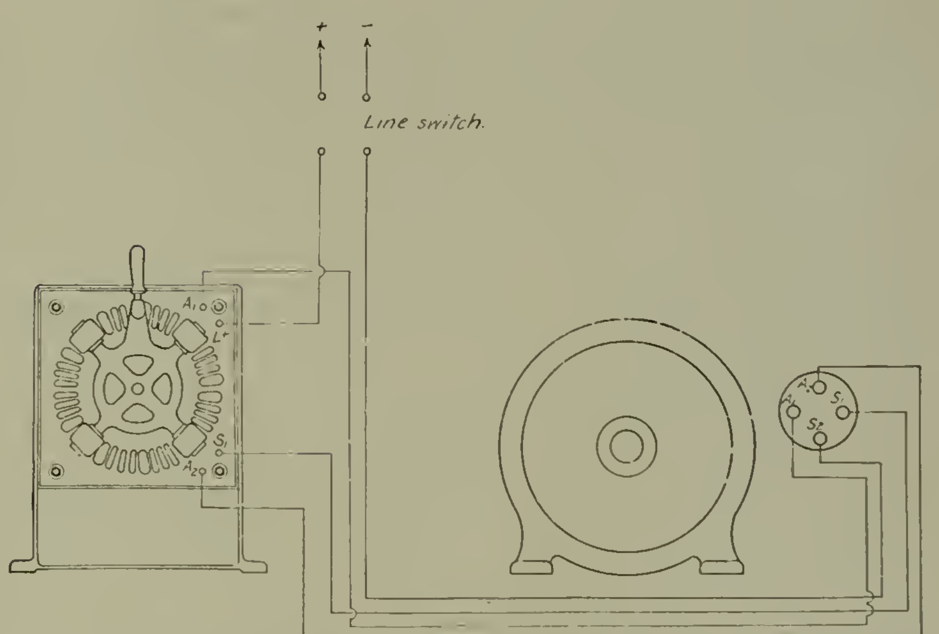


FIG. 21.—SERIES WOUND TYPE S MOTOR AND TYPE 177 CONTROLLER, 2 TO 10 H. P., FRAMES 1 TO 6, INCLUSIVE. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

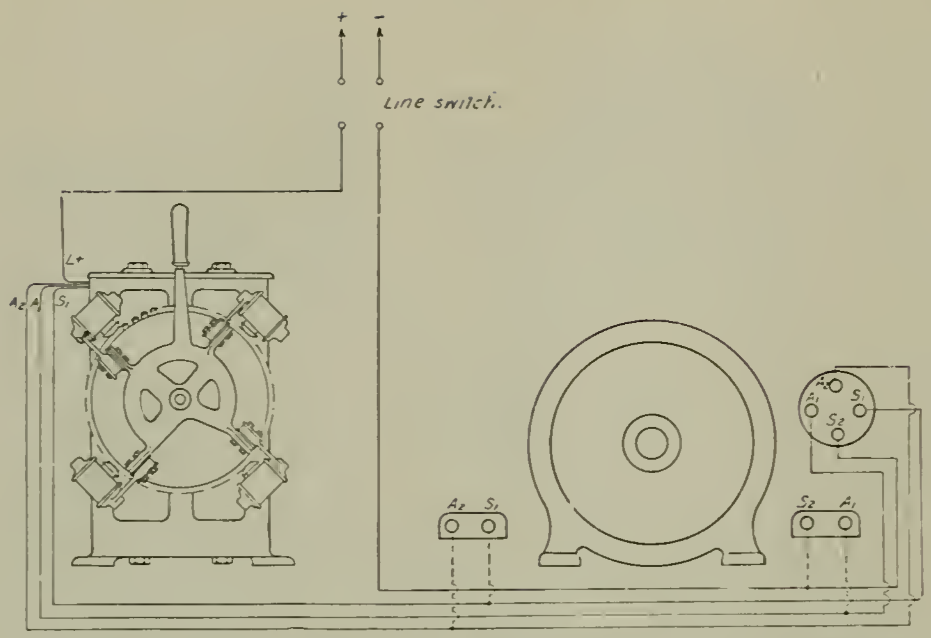


FIG. 22.—SERIES WOUND TYPE S MOTOR AND TYPE 178 CONTROLLER, 10 TO 30 H. P. AT 110 VOLTS AND 10 TO 75 H. P. AT 220 VOLTS—FOR FRAMES 1 TO 6, INCLUSIVE, CONNECT BY FULL LINES. FOR FRAMES 7 AND ABOVE, CONNECT BY DOTTED LINES. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

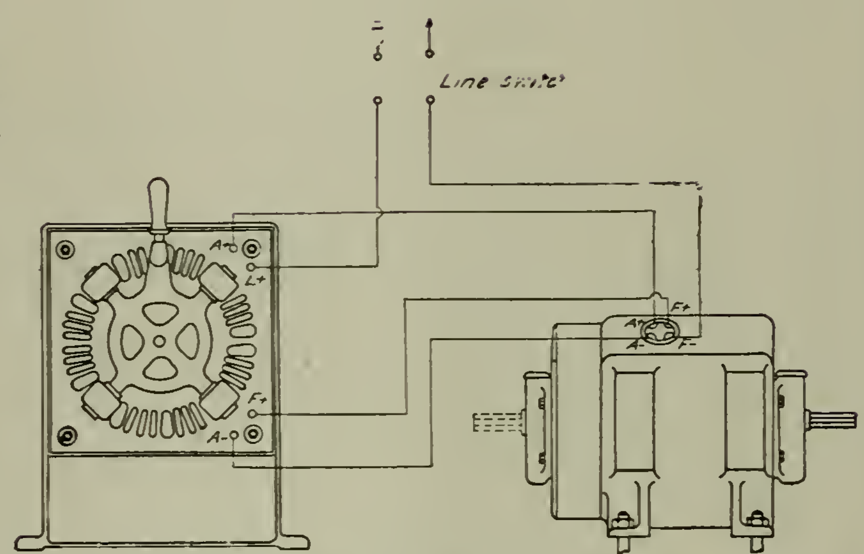


FIG. 23.—TYPE K SERIES MOTOR AND TYPE 177 CONTROLLER, 2 TO 10 H. P. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

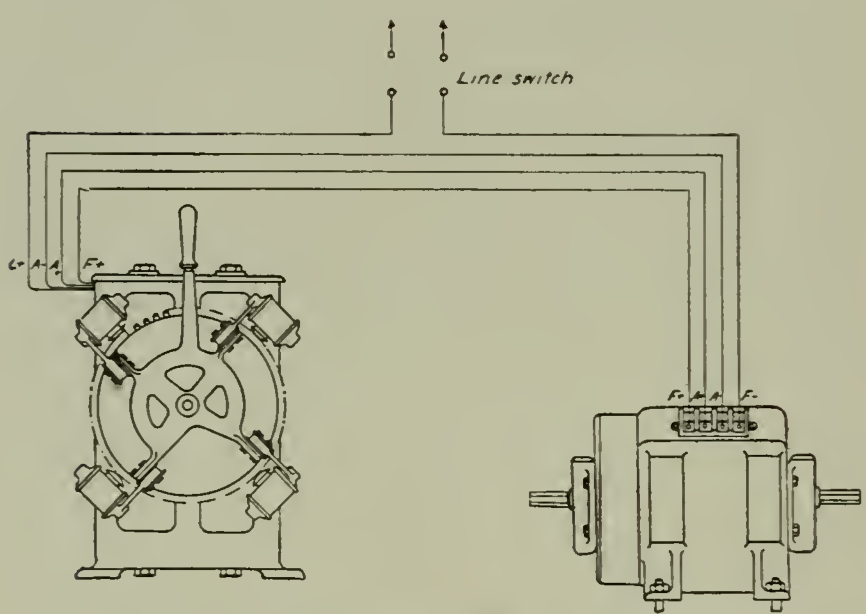


FIG. 24.—TYPE K SERIES MOTOR AND TYPE 178 CONTROLLER, 10 H. P. AND ABOVE. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

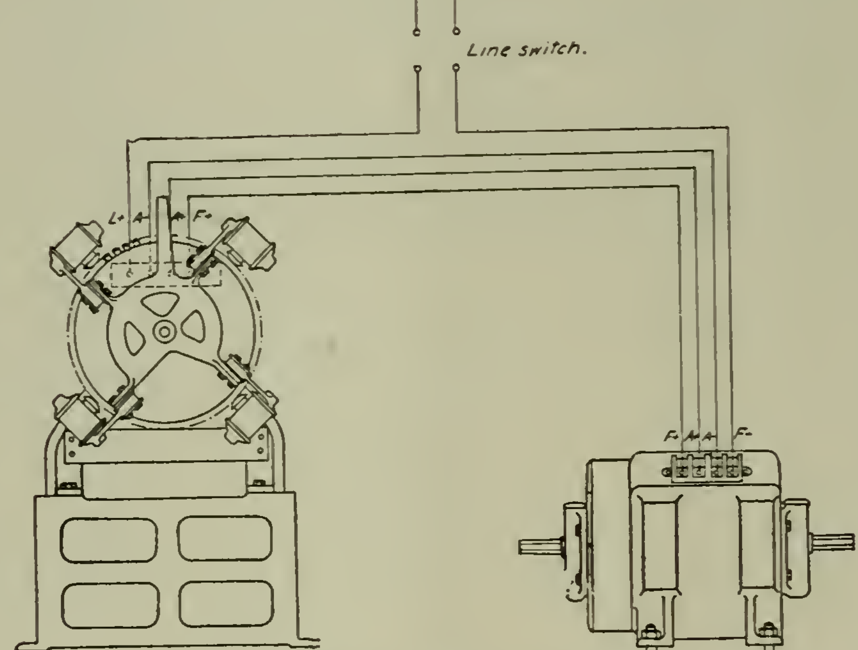


FIG. 25.—TYPE K SERIES MOTOR AND TYPE 179 COMMUTATOR CONTROLLER, 10 H. P. AND ABOVE. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

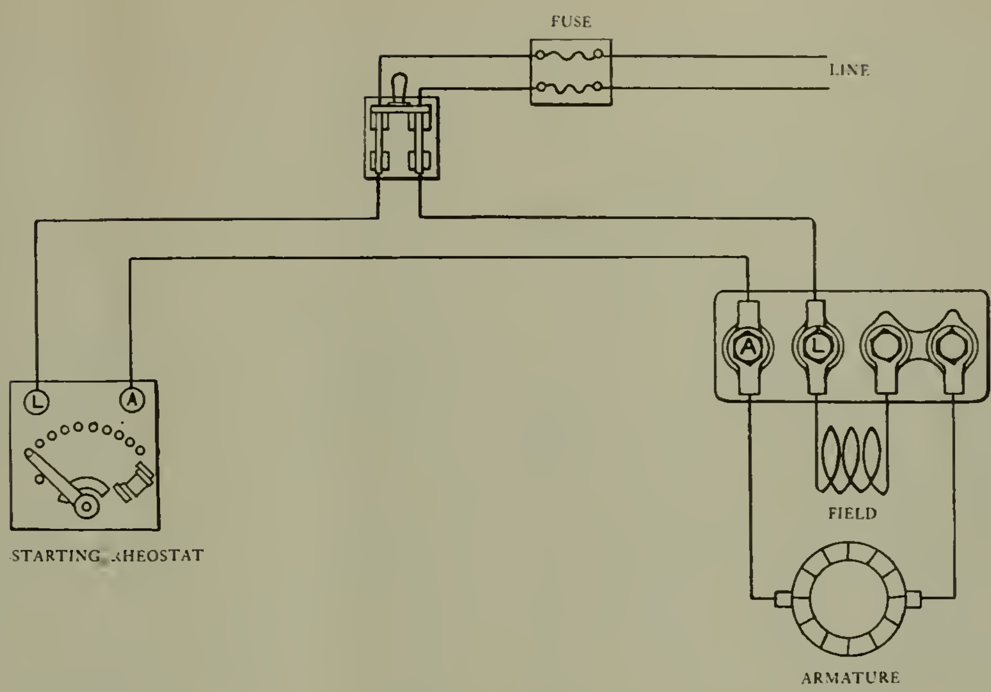


FIG. 26.—SERIES WOUND LUNDELL MOTOR, 1/4, 1/2, 1, 2, 3 FRAMES. SPRAGUE ELECTRIC COMPANY.

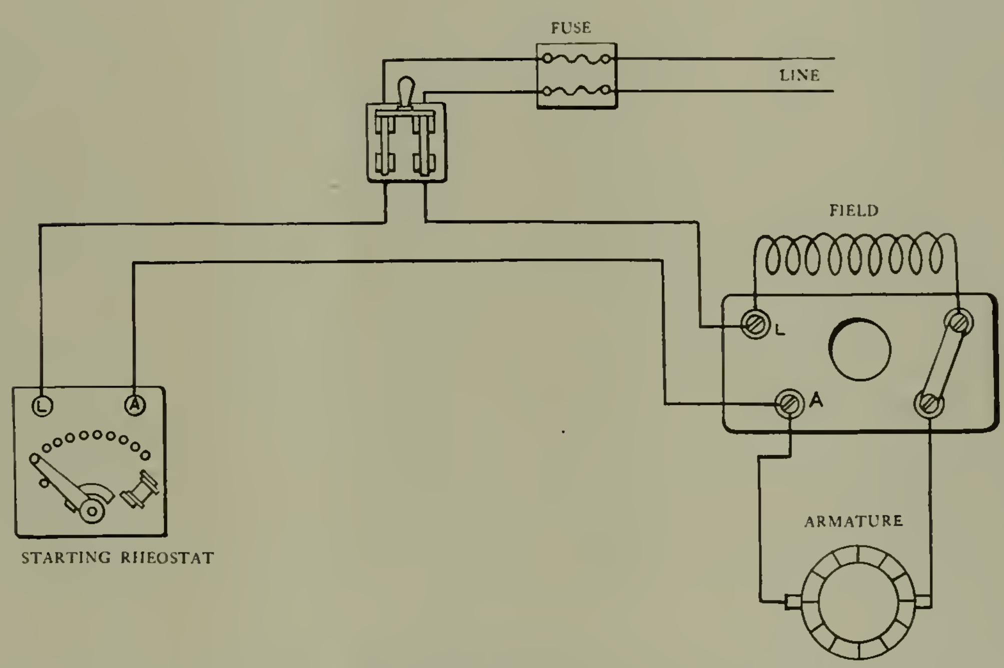


FIG. 27.—SERIES WOUND LUNDELL MOTOR, 4, 5, 7½, 10 FRAMES. SPRAGUE ELECTRIC COMPANY.

Electric Power Notes—New York

In the February number, as will be remembered, some particulars were given of the electric sign business of the United Electric Light and Power Company. In the present instance some details of the company's power business will be given.

The contract for electric power is based upon monthly consumption, according to the following schedule:

For the first 200 kws.		10c. per kw
From 200 to 400 kws.	Excess over 200	8c. " "
From 400 to 3500 "	" " 400	6c. " "
From 3500 to 7000 "	" " 3500	5c. " "

The company's services is entirely alternating current, the power distribution being 2 phase 210 volts and the lighting single-phase, 105 volts. In many cases, however, where only single-phase circuits have been installed, small single-phase motors may be used to a limited extent, if the load is a steady one. No set rule is followed for limiting the size of a single-phase motor, each case being considered separately. For instance, while ordinarily not more than a 1-horse-power motor would be used on 210 volts, single-phase, and not more than a 1/4 horse-power on 105 volts, in one case a 10-horse-power single-phase motor is driving refrigerating apparatus. As no two-phase circuit was in the vicinity, and as the load was the same throughout the twenty-four hours, the extention of the limit was considered justifiable.

When both lighting and power service are furnished in the same building separate circuits are run from the service. It is only in the case of small dental motors and fan motors that current is taken directly from the lighting circuit.

The company's power service is in use in a large number of apartment houses for operating two-phase elevator motors. Nearly 500 buildings are equipped at the present date. At the end of 1905, the number was 332, so that during 1906 the company increased its number of elevator motors by 168.

One of the interesting installations is that at the "Claremont," a restaurant in Riverside Park near Grant's Tomb. Like all up-to-date restaurants, the Claremont is supplied with a dish-washer, driven by a Wagner 1-horse-power 104-volt single-phase motor, running at 1800 revolutions per minute. In the kitchen, two ventilating fans are driven by a 1-horse-power 208-volt motor, running at 1750 revolutions per minute. The motor is belted to a counter shaft, which in turn is belted to the fans. For polishing the silver, a buffer is driven by a ½-horse-power 208-volt motor, running at 1800 revolutions per minute.

In the making of bread, also, the cleanliness and despatch of the motor-driven machine are beginning to be appreciated. As yet, the company has but one customer of the smaller class, a 2-horse-power motor being used to drive a dough-mixer and a bread-moulder. The former machine can mix 2 pounds of flour in 10 minutes while the bread-moulder, it is claimed, will save 35 cents in labor to every barrel of flour.

Fort George, a summer amusement park, also furnishes a field for the use of the company's power. Here the usual array of Ferris wheels, scenic railways, carousels, moving stairways, candy-pulling machines, automatic pianos and orchestrions are all operated by electric power supplied by "The United Co."

Perhaps the best example of the convenience and reliability of the electric drive is furnished by an installation of a 7½-horse-power single-phase Richmond motor for driving 2 sausage machines. The motor is of the two-phase type operating on 208 volts at 1720 revolutions per minute. It drives a No. 52 "Enterprise" meat-chopper, and a No. 27 "Silent Cutter." The former machine has a capacity of 1500 pounds of meat an hour, while the latter will chop from 800 to 1000 pounds in an hour. Chopping by hand two men could turn out only 50 pounds an hour. The proprietor formerly used a gas engine for driving his machines, but the difficulty in starting it, particularly when a "rush" order came in, compelled him to seek a more reliable means of doing the work.

Outline Lighting

By HOMER HONEYWELL

SOME interesting particulars of a new business campaign were given by the author in a paper presented at the recent gathering of the Northwestern Electrical Convention. About the first of February, 1904, the Lincoln (Neb.) Gas and Electric Light Company organized a new-business department, with a competent manager at its head, and started out with well-defined ideas as to the desirable classes of business and the effects on the station load. It was the aim to take on a steady load that would run from dusk until midnight each and every night during the year. To that end a flat rate was figured out, based on the Doherty rate of $1.80 per year for each connected 16-candle-power lamp, or its equivalent, $12 per year for a customer charge and six cents per kilowatt-hour for current used, all subject to a discount of 10 per cent. for prompt payment, and on the actual number of burning-hours as applied to Lincoln.

No flat rates are taken on inside lighting. The company makes free renewals, and does it whenever the men see a lamp out.

The outlining is installed free when two-year contracts are taken, and the cost of installation figures about 38 cents per 4-candle-power lamp installed, the lamps being placed 18 inches apart. By this method a number of small stores were induced to light up. The small merchant with a strip of 17 4-candle-power lamps over his sign, burning each night from dusk until midnight, turned on and off by the company's man, pays $5.30 net per month.

At the present time there are in use the equivalent of 10,000 4-candle-power lamps for sign, outlining, and window lighting. The service is used by barbers, shoemakers, livery stables, undertakers, second-hand stores, boot-black stands, butcher shops, lunch cars and popcorn stands—in fact, all kinds of business. No business is too peculiar or small to be a prospect. The company has one customer, a clothing store, whose sign, outlining and window lighting amounts to 960 4-candle-power lamps.

It is claimed that the display lighting is one of the most valuable assets of Lincoln, and it certainly has a far-reaching effect—people promenade the streets, and can inspect the goods displayed at their leisure. All the large-size show windows have light-colored stucco ceilings and are lighted by trough reflectors. Artistic, well-dressed, frequently-changed windows are the rule in Lincoln. Progressive merchants, aided by the Doherty rate, are responsible for the attractive appearance of the streets at night. Had the attempt been made to install display or advertising lighting on a flat meter rate, even though the rate was lower than the present rate, it is more than doubtful if the merchants could have been interested. An appeal to the merchants' civic pride and a showing of the very small cost for a big lot of good advertising works wonders.

Six o'clock closing is the rule in Lincoln every night except Saturday, and it would seem that a fine field for display lighting would be offered in the smaller towns where the stores keep open every night or two nights a week, and the people have few places to go. Well-lighted windows and outlining displays will bring the people to the streets at night and cause the merchant to put better goods in his window and display them to better advantage.

In soliciting, the company is always careful to impress on the prospect's mind that the outside and window display is an advertising, and not a lighting, expense. Solicitors are paid a small salary and a percentage of the increase in gross revenue over the corresponding month for the previous year.

Each solicitor's commission depends on the number of points he has in proportion to the total number turned in, and points are given for each dollar of estimated revenue. Industrial business is worth 10 points; additional inside consumption, 10 points; new contracts, five points; outlining or signs until 12 o'clock, 10 points; outlining or signs less than 12 o'clock, five points; outlining or signs on meter, three points. If business is taken from the competitor, the points are doubled. Each man is responsible for his own territory, and is keen to hold business, as well as to get new business.

Personal solicitation, newspapers, mail advertising and personal letters are used, and the cost of getting business to the company for the last three years has been 43 cents for each one dollar of increased revenue procured.

Of the advertising done at the start, the author believes that the mail advertising was the most valuable. It was done on a fairly large scale and in a way that was new to a great many people. The first week one letter or card was sent out, the next week two, and so on, until the prospect received a letter or card every day. The mail advertising helped to put the prospect in a receptive mood, and the solicitor was able to close the contract quickly. The combination of mail advertising and personal solicitation is a strong combination.

The effect on the station has been gratifying. The increase in peak load has been 23 per cent., while the sales have increased 60 per cent.

The sale of signs was not pushed particularly until the company had made considerable headway in the other forms of lighting. At the present time 48 lamp-lettered signs are in use, all of them bought outright from the local sign-builder. The reason for installing free outlining on two-year contracts and not installing free signs is apparent. The outlining can be taken down, be repainted and put up again anywhere at a very small cost, while a sign to be used again would have to be remodeled at a considerable expense. Then, too, the first investment for a sign is considerable, and if the merchant is not required to carry the investment he feels freer to discontinue the use of the light. During the last three years not over five or six outlining contracts were discontinued where the merchant remained in business, but, on the other hand, the display of most of them was increased.

There are in use 8,500 4-candle-power lamps for sign, outlining and sidewalk showcases. All these are on a flat rate. For window lighting 900 16-candle-power lamps are used.

Outlined roof signs also seem to be a popular and cheap method of advertising. So far all the outlining has been done along straight lines, but attempts are now being made to relieve the plainness by the use of curves and circles.

The sales for the last year have been 689 kilowatt-hours for each kilowatt connected. The Sunday output runs about 63 per cent. of the average weekly output and is largely due to flat-rate lighting.

The city has a municipal street-lighting plant, and the traction company supplies some commercial light and power, but the generous display lighting is not due to competition, because the so-called competitor has but three outlining customers and two customers using signs of respectable proportions.

DISCUSSION

In the discussion following the reading of the paper, C. A. Parker, of Detroit, said that there seemed to be quite a tendency to revert to the flat rate in such business as outline and sign lighting, especially in the case of small business. The small man wants to know how much it is going to cost him, particularly in such classes of business as druggists, barber shops, and the like.

F. W. Insull, of Chicago, said that his company had made a number of flat-rate, two-year contracts, based on the number of hours use of current and the number of lights installed. The plan works well. Many customers are a bit afraid of meter rates, and if one talks window lighting to them, they will ask how much it will cost. If they are given a rate per kilowatt-hour, and the cost is figured out, they are still a little afraid. But the moment a flat-rate proposition is made them, they are interested. The company's patrol turns these lights on and off. Many small towns are on the company's circuits, and it is not a difficult problem to get the window-lighting business in them.

In a majority of the very small towns, said Henry Almert, of Chicago, the business district is confined to just two or three blocks, generally all on one street, and he had seen but very few of the towns where the company has been warranted in sending an inspector or someone to turn these lights on and off. His experience was that the time-switch had not been very satisfactory. He had, however, within the last 90 days, spoken with three or four central-station men, some of them large ones, who report very satisfactory results from the time switches. It had been his idea to put into use soon, in one town, a time switch on each side of the street in the business district, and endeavor to get outline lighting such as the author referred to. He was also going after window lighting and would endeavor to get and keep these lights on a flat-rate basis from dusk until two o'clock. At present, in these small towns at certain seasons of the year the stores close at six o'clock and at other seasons at nine o'clock, and everything seems to be off at the latter hour.

The line of letter advertising will show results in larger cities where the store windows are lighted, even though they are closed. He would endeavor to convince the merchant that lighting could be profitably used for window display, and that in the small towns, if the windows are lighted, people would come down after dinner in the evening to see the shop-window display, and the desire to purchase is thus created.

J. S. Allen, of Lake Geneva, Wis., had found that for a very small amount ($4 a month) the night policeman could be hired to turn off the light. They had made contracts in such a way that the consumer turned on his own lights, and had found very few instances where that privilege was abused; but that must be confined to outside sign or window lighting. By this plan the company had created an exceptionally good feeling among their customers.

Regarding rates, Mr. Allen said that they had tried the flat-rate and found it unsatisfactory. They then went to the other extreme and placed everything on a meter basis. It was only within the last few years that they had come to realize that a combination of the two was advisable. They were now taking a middle ground, which, it seems to the speaker, was a rational one to take, so far as he could at present determine. Of course we have had during that time a great many different rates advocated, rates that were very beneficial, such as the Doherty rate and many others that we know about; but it seems to me that the combination of the flat rate and the meter rate is the most enlightened mode of selling current to the public at the present time.

And this question of a combination of flat and meter rates gives us an opportunity to get closer to the customer. It gives him an insight into our way of doing business that convinces him of our fairness; and that conviction is so pronounced that it has worked great benefit to the central station.

Tests of Carbon and Metallic Filament Lamps

SOME interesting results of tests of carbon, osmium and tantalum lamps are given by J. T. Morris in a recent number of "The Electrician," of London.

A fact that has not received much attention is the effect that metallic filament lamps will have on a machine running on a lighting load. If for any reason the pressure fails and the whole load is switched on again at full voltage (the normal current being, say, 100 amperes), then the momentary current on closing the switch will be for carbon filament lamps 50 to 60 amperes, whilst for tantalum lamps 630 amperes, and for osmium about 790 amperes. Doubtless these effects are largely diminished by the inductance of the circuits, but with a metallic filament lamp load the effect should be plainly noticeable in the increased sparking at the brushes of the generator, not to mention at the switch contacts.

With regard to the life of the lamps the author says that as a carbon lamp lasts longer on alternating current than on direct current, theoretically the tantalum lamp should show an increased life on alternating current, provided, of course, that the maximum temperature attained during one cycle is not sufficient to melt the filament. This being so, it is at first sight rather remarkable that a decided increase in life should be noticed when the tantalum lamp is run on an alternating-current circuit. When we consider, however, how near the filament at normal voltage is to its melting point, and also bear in mind that it is alternately heating and cooling (this alternation takes place at twice the frequency of supply) and that consequently it is subjected to repeated stresses, it is possible that part of the decrease in life is due to this, and resembles the breaking of a bar by the repetition of small stresses well within the elastic limit.

The tantalum filament apparently expands a fair amount when it is heated to its normal temperature, and this expansion causes the lamp to emit a sound immediately on switching into circuit, the noise being due to the filament moving over the wire supports.

After burning for some time the filament changes its nature and becomes, as is well known, more crystalline. When new it appears as a straight parallel sided wire, but after burning for some time it assumes a more or less disjointed appearance, as if it had been cut into very small pieces and these pieces had been fitted together without proper alignment.

These results would seem to indicate that one direction in which an increase in the life of the tantalum lamp could be obtained when used with alternating currents would be in giving greater freedom to the filament—if feasible, a freedom similar to that which the filament of the ordinary carbon lamp possesses. Possibly it might be found to answer the purpose to replace the usual zigzag of *straight* filament by a corresponding arrangement made from a piece of tantalum wire previously wound in a *very fine spiral.*

Warrantable Expense for Meter Testing

By OLIVER J. BUSHNELL

IN discussing the question of warrantable expense for meter testing, in a paper read at the recent convention of the Northwestern Electrical Association, the author said that probably the most important point to be considered in connection with the subject is the frequency with which meters should be tested. Most central station managers believe that, as a matter of general policy, meters should not run much longer than a year without testing, both as a protection to the company against loss, and as an assurance to their customers of the correctness of their bills. These men would doubtless also assent to the proposition that it would pay to give special attention to meters involving a large amount of income. We can not, however, arrive at the proper frequency of tests with any correctness without a study of the conditions which affect meter accuracy.

In all meters the revolving part is mounted on a jeweled bearing which in time becomes rough; again, the permanent drag magnets are liable to change from aging, rough handling, or short circuits; again, in commutator-type meters the commutator and brushes will wear and become rough from sparking; lastly, all meters are influenced more or less by vibration, dampness, dust, and other conditions of installation. Jewel wear, the first of these causes which affect meter accuracy, is influenced chiefly by the weight of the moving element, the number of revolutions of the shaft, and vibration. The first of these is constant for a given type of meter, the second is easily ascertained from the meter readings, and the influence of the last can be learned from successive tests.

Just how much wear a jewel will stand is somewhat uncertain. Sapphire, which is almost universally used, is of uneven structure, and variations in the quality of jewels can not be eliminated by the most careful inspection in their manufacture. In a report on "Jewels and Pivots" in commutator meters made a few years ago by the Meter Committee of the Association of Edison Illuminating Companies, it was suggested as a result of about 200 time tests that 800,000 revolutions be taken as the limit of wear of sapphire jewels in meters not subject to vibration, with half that number as the limit where vibration was constant. Since that time commutator-type meters have been very much improved and in the latest type the weight of the moving element is only one-third as much as formerly.

It does not appear that the decrease in jewel wear is directly proportional to the decrease in weight of the moving element, but it is probably nearly so. It would doubtless be more accurate to adopt a different limit of revolutions for each type of meter in which the weight of the moving element is different, but for convenience 1,000,000 revolutions have been quite generally adopted as the limit of wear for sapphire jewels in all commutator meters.

The writer has not any direct data on the wear of sapphire jewels in induction meters and here again the weight of the moving element varies in different types of meters; but from a comparison of these weights with those of the moving elements in commutator-type meters and from the lesser number of jewels found defective in annual tests of induction meters, it is evident that a jewel will stand at least two or three times the number of revolutions in an induction meter that it will in a commutator type. The writer believes the limit of wear of 2,000,000 revolutions, adopted by a large Eastern Company, is certainly safe.

About two and one-half years ago there was discovered a process of cupping diamond jewels for meters and since then they have come into considerable use. One company has made tests of these jewels up to 9,500,000 revolutions without the stone showing any wear, but in some of the tests the shaft points became so flat as to introduce considerable friction. What the average life of the jewel is the author can not state, but believes that it can safely be taken at five times that of sapphire jewels, and that it is probably more than this.

Although the adoption of diamond jewels largely removes jewel troubles, the elements of magnet change, commutator friction, and deterioration due to local conditions still remain to be considered. These are so uncertain that they can not be classified directly and the old limits of registration between tests originally adopted for sapphire jewels have been adhered to quite generally among those companies which are using diamond jewels on account of possible deterioration from these other causes.

There is an important fact also in meter construction to be considered in this connection which makes the size of the meter an element to be considered in determining the frequency of tests. Meters of a given make have approximately the same full load torque in all sizes. It follows that a meter of large capacity will at times necessarily operate with much less torque than a meter of small capacity with a resultant increased liability to error. To illustrate, suppose a five-ampere 100-volt meter and a fifty-ampere 100-volt meter are both recording a load of one 50-watt lamp. The first is running on a ten per cent. load with ten per cent. of its full load torque and the other on a one per cent. load with only one per cent. of its full load torque. As the full-load torque of both meters is the same, it follows that the small meter has ten times as much torque on one lamp as the larger one. Suppose also that it takes one-half of one per cent. of the full load torque to overcome the friction of the bearings, the small capacity meter would run five per cent. slow while the large capacity meter would run fifty per cent. slow on the fifty-watt load. It is at once evident that meters of large capacity should be kept in better condition, and more frequently tested than those of small capacity.

In accordance with the foregoing considerations meters should be classified for testing somewhat as follows:

First—A limit should be set within which all meters should be tested.

Second—A classification should be made according to sizes so that the large meters will be tested oftener than the small ones.

Third—A classification should be made according to the work done by the meter so that they will not be allowed to exceed a fixed number of revolutions between tests.

Fourth—Changes in classification should be made to allow for local conditions as made evident by the results of successive tests.

In order to find out the methods now used in meter testing, the writer sent out a number of questions on the subject to twelve of the largest companies in the country. The first two were as follows:

How often are your electricity meters tested?

On what basis is the frequency of tests determined?

The following are four of the answers received:

First Answer—(1) By inspection once a year. (2) The basis of the frequency of tests is assumption that meters should be inspected at least once a year.

Second Answer—(1) From one month on largest meters to fifteen months on induction meters in residential districts, all meters coming as a rule within either one, three, six, nine or twelve months' classes. (2) On the basis of the work which the meter is doing, the intention being to test at every million revolutions of the disc in direct-current meters and every two million revolutions in induction meters.

Third Answer—(1) As a general rule once in twelve months; some are tested monthly, some every three months, and some every six months. (2) The period is decided by the amount of the monthly registration varying, of course, with the various sizes of meters. All meters tested more than once a year are equipped with diamond jewels. Our data shows that a meter equipped with a diamond jewel need not be tested until it has made a million or more revolutions.

Fourth Answer—Our meters are tested each time they are returned to meter shop, regardless of time they have been installed. Others that have been installed three years are changed, tested and cleaned up. We do not test meters on customers' premises unless requested to do so.

Commenting on these replies, the writer believes that the first system must result in the meters which measure the largest consumption showing the poorest accuracy.

The second tends to keep all meters on a level of accuracy at the same per cent. loads, but will result in a disproportionate loss from the large capacity meters on light loads.

The third system, which takes the size of the meter also into account, will not only keep up the accuracy of the meters under heavy service, but will also maintain the accuracy of the large capacity meters operating considerably under light load conditions.

The fourth system, the writer believes, is faulty both in allowing too long a time between tests, even for induction meters, and also in the method of testing, which will be taken up later.

The classification adopted by the writer about two years ago for commutator meters was as follows:

Annual tests for meters of five to ten amperes capacity.

Semi-annual tests for meters of fifteen to fifty amperes capacity.

Quarterly tests for meters of seventy-five amperes capacity and above.

Meters making over 1,000,000 revolutions of the disc between tests on above classification to be changed to more frequent class so as not to exceed that number between tests, up to the quarterly class.

It has not been thought necessary to test any meter oftener than once in three months. Where a meter has not retained its calibration for this length of time an investigation has been made. Such rapid loss of accuracy is usually found to be due to commutator trouble caused either by excessive vibration or heavy momentary overloads. In the first case the meter has been moved or mounted on a spring-board, and in the latter a larger meter has been installed with a better resultant accuracy than if the old meter had been left as it was and tested monthly. All meters tested quarterly have been equipped with cupped diamond jewels and the semi-annual class are being so equipped as rapidly as they can be obtained.

A study of the data compiled from the tests made according to the foregoing schedule reveals some interesting facts. In the first place the accuracy of the meters improves in an increasing ratio the more frequent the testing. The quarterly tests at one-half load show fifteen per cent. more of the meters to be accurate than the annual tests, and ten per cent. more than the semi-annual tests, while the improvement shown by the light load tests, which are made at one-tenth load, is still more marked. The same increasing ratio of improvement the more frequent the testing, is seen in the average accuracy obtained from these tests which was as follows:

Annual tests	½ load	97.3%	1–10 load	89.6%
Semi-annual tests	½ load	97.8%	1–10 load	90.8%
Quarterly tests	½ load	99.1%	1–10 load	96.5%

An important showing from the data of the meters out of calibration is the ratio of the meters slow, to those fast, which at one-half load was more than two to one, while at one-tenth load it was five to one. On still lighter loads the ratio would doubtless be further largely increased. It was also shown by the data that the type "C" commutator meters maintained their accuracy much better than the older types with heavier moving elements, especially on light loads where the greatest improvement was needed. A better accuracy was shown by the annual tests of type "C" meters than by the semi-annual tests of meters of the older types.

The writer has not given the above schedule, however, as a model, but rather as an illustration. In the light of the results obtained he expects to make some changes for the coming year. It would seem as though some differences should be made in the classification of commutator meters as regards the type, though the use of diamond jewels in all of the older types may largely obviate the necessity. In particular, however, it would doubtless be advantageous to test more of the meters quarterly, placing at least more of the meters of the older types in this class.

Induction meters have so far been classified by the writer on an annual basis for testing. Owing to the light weight of the moving element and the absence of commutator friction these meters retain their accuracy much better than the commutator type. Data compiled from about 14,000 annual tests showed an accuracy almost identical with that of commutator meters under quarterly testing. As it is probable, however, that the meters measuring the largest consumption are below the general average, it is expected the coming year to test the larger meters and those showing over 3,000,000 revolutions between tests on a semi-annual basis.

Having decided on some schedule for periodic testing an important point to be next considered is the advisability of making installation tests. It is well known that meters transported some distance are liable to slight changes in calibration, also that direct-current meters, unless connected according to polarity markings or even if so connected where influenced by magnetic fields from other conductors, will show some error on light loads. The questions sent out by the writer brought back the information that two of the largest companies in the country make a test on every meter installed before the first bill is rendered, notwithstanding the fact that the meters have previously been corrected in the testing room. In the Chicago Edison Company it has been the practice to have all meters after installation inspected, and cleaned and adjusted if necessary, so as to run freely on a light load.

In order to get some information as to the condition of meters after their installation and as to whether an inspection or test is advisable, the writer made 100 tests of commutator meters and 100 tests of induction meters immediately after they were installed, these meters having all been adjusted in the shop before being sent out. The accuracy after installation as shown by these tests was rather disappointing, especially so in commutator meters on light loads. Tests were then made on an equal number of meters after the usual starting inspection. These tests showed a decidedly improved condition of these meters over the others, especially on light loads, and a better accuracy than that shown by any of our periodic tests. Still there were some meters which showed a change of from five to ten per cent. in their whole calibration.

It is particularly desirable that the bills of a new customer should be absolutely correct. If a meter is slow for two or three months and then is corrected, it leads to the suspicion when the bill goes up that the company is increasing the bills arbitrarily after it feels sure that the customer will be permanent. The conclusion seems warrantable that both alternating-current and direct-current meters involving considerable consumption ought to be tested within one month after installation. The direct-current meters will be left in a more permanent condition if allowed to run for two weeks before testing so that the commutator will have become oxidized. For the large class of small meters for offices, apartments, and houses a careful inspection appears to be a sufficient safeguard. Perhaps a good division would be that meters which it is advisable to test oftener than once a year should have an installation test and others an inspection only.

The methods of testing should have some attention, which of necessity is very much abbreviated. The first important point is to have accurate standards. A laboratory standard voltmeter, a standard shunt and a precision indicating watt-meter make excellent working standards. These should be returned to the factory occasionally for calibration unless the company has a laboratory where they can be checked. In the absence of these a set of the working instruments should be kept for checking other instruments only, and returned to the factory for recalibration every six months.

Meters can be tested on the customer's premises or brought in and tested in the shop. Some have contended that the latter is the more accurate way, as conditions are more favorable for correct measurements. The necessity for installation tests which is shown in a previous part of this paper proves conclusively, however, that meters should be tested under local conditions in which they are to operate, and after all danger of change from transportation is over. Even if a meter is taken out and installed with the utmost care so as not to disturb the original calibration in the slightest, frequently some change in the light load adjustment is necessary to adapt it to local conditions of vibration or adjacent magnetic fields.

Four methods of testing are in general use:

First—With ammeter, voltmeter and stop watch.

Second—With calibrated resistance, voltmeter and stop watch.

Third—With indicating wattmeter and stop watch.

Fourth—With check recording wattmeter.

The first method is used only on direct-current work and the second should be only so used unless the resistance is absolutely non-inductive. Self-contained shunt Weston ammeters, on account of temperature error, should not be used except in small sizes, and even then the current should be kept on the instrument only during the time necessary to make each test. Resistance shunts with negligible temperature coefficient and milli-volt meters should always be used for measuring large currents. The indicating wattmeter should be used only for alternating-current work, as it is not reliable to direct current, owing to the influence of external magnetic fields. The check-recording wattmeter has the advantage of not requiring a stop watch, yet if a portable load is used the inspector can tell the per cent. load on the meter with sufficient accuracy.

An ordinary meter can be placed in a carrying-box and used for checking, but it is better to use one of the special test meters of which there are two or three kinds on the market. These meters are built with several field windings so that the full torque of the meter is available at different loads. The meter under test can accordingly be tested with equal accuracy at heavy and light loads by connecting to the field coils of the corresponding capacity in the test meter. This method is particularly advantageous where a meter must be tested on a fluctuating load.

Each method of testing has its advantages and each will be found best doubtless for some kinds of work. The writer has had all in use and finds no particular advantage of one over the others in the amount of work which can be accomplished. He inclines to the belief, however, that the test meter with several field windings will soon have more general adoption and prove slightly more economical than other methods.

The number of meters which can be tested by an inspector in one day has been variously reported by the different companies from which data was secured at from six to ten. The writer believes an average of about seven should be obtained in testing commutator meters and eight or more in testing induction meters.

The use of diamond-cupped jewels is recommended in all of the older type commutator meters where the jewel is subject to heavy wear. Sapphire jewels may be repolished once, but the stones should be removed from the screws and polished and inspected the same as new stones and set in new screws. If polished in the old setting some of the powder is apt to be left in the screw and cause trouble. Pivots also may be used a second time if they are carefully repointed and polished. A new pivot or shaft should always be inserted when a jewel is changed.

It is advisable to test meters at two points. The light-load calibration is usually made at one-tenth load and heavy-load calibration at from one-half to full load. It makes no difference whether one-half or full load is used as far as the final calibration of the meter is concerned, but the reports of the meters as found would doubtless show better on a full load test. One-half load is used by the writer as being nearer the running condition of the meter.

Whatever tests are made an accurate record should be kept and the results carefully tabulated. Sample forms for this purpose are appended to this paper. Only by an accurate knowledge of the condition of his meters and a study of the results of his testing can a central station manager satisfy himself as to whether or not he is warranted in the expense he is incurring.

We come now to the question which many may consider the most vital to the subject. What will a thorough system of meter testing cost? Whatever is said on the subject will doubtless be questioned by a good many, as the practice of different companies varies so much, both as to the amount of testing and the expense items which are included under this head. The expense in the same company also would vary with the character of the customers served and the amount of consumption measured. Nevertheless approximate figures may be arrived at as a general guide to good meter practice.

These figures might be expressed in cents per kilowatt-hour generated output or in per cent. of metered income, but it seemed to the writer that they would be more readily understood and of more accurate application if based on the number of meters in service. The writer collected some data on this subject, but the classification of accounts varies so in different companies that the figures are not readily comparable or all applicable to the expense of meter maintenance only. Meter testing, in the broad sense we wish to use, should include all maintenance expenses and cover periodic testing, shop testing and repairing and installation tests and inspections.

The money actually spent on this work in different companies from which figures were received varied from $0.48 to $1.63 annually per meter installed. The writer must accordingly draw largely on his own experience and the figures of the companies with which he is connected for his conclusions. Naturally the expense for direct-current meters is greater than for induction meters. It is customary also to distribute direct-current largely in business districts, where the wear on the meter is greater on account of longer use, and alternating current in residential districts. A thorough system of testing based on the principles outlined in this paper can not be carried on, according to the estimate of the writer, for less than about seventy-five cents per meter installed for induction meters, and $1.50 per meter installed for commutator-type meters annually.

It is possible that there are some companies with few large customers and little increase in business which could do the work for two-thirds these figures, but for a progressive growing company they are not too high. These figures include the cost of all instruments, apparatus and supplies necessary for carrying on the work as well as the cost of material used in the meters and labor. The salaries of meter testers is assumed to be from $50 to $65 per month for the most part and helpers for testing large meters at $40 per month.

It must be borne in mind that the amount given will not be spent on every meter. A third of it would cover the cost for a large part of the meters which are tested annually, but two or three times this amount would be necessary for other meters which are tested quarterly. The general average is also brought up by the cost of installation tests and inspections, and of repairs to defective meters, together with the cost of instruments and general supplies. These figures are based on a system of testing which experience has shown to be advantageous. It is not the intention, however, to limit the expenses to these amounts as further experience may demonstrate the advisability of still more expenditure for this purpose. Of course, for meters measuring little consumption, the limit of expense is reached when reasonable accuracy is obtained, but for meters measuring a large consumption the cost of meter maintenance may be inconsiderable as compared with a loss of a fraction of one per cent. in registration.

The high cost for direct-current meters is partly on account of the introduction of cupped-diamond jewels. These cost about five times as much as sapphire jewels, but their use is fully warranted both by the better accuracy obtained and by the longer life of the jewel. The Chicago Edison Company has put in service over 3,000 of these jewels in the last two years,

METER TEST.

No.................... Dist.............. Day..............
Name ....
Address. ....
Installation.................... for ....
Location of Meter......................................
Watt Meter No.......... Size.......... A........ V.......... W
Reading.......... X........ Testing Const.......... Seal No..........
Top Bearing.............. Jewel.............. Pivot..............
Shunt Coil.............................. Creeping..............
Com. and Brushes ....

	Volts	Amperes	Rev.	Sec.	Standard Watts	Meter Watts	Per Cent.	% Load
Found								
Left								

Report ....
....
....
Max. Meters No.......... is.... Reads.......... No...... is.... Reads
Left Meter.................... Left Fuses....................
Tested with.................... Lamp Bank....................
Time of Test.......... To.......... Date....................
Checked by.......... Entered....................
.... Insp.

METER INSPECTION.

Mr...
....

Will you kindly allow our Inspector to test the Electric Meters in your premises and sign and return this slip to him on completion of the test?

CHICAGO EDISON COMPANY.

Date..............................

Signed .... Consumer.

half of which have been in use over a year and yet only about one per cent. of them have become worn. Compare these results with data on sapphire jewels of which forty to sixty per cent. are found defective in annual testing and the value of the cupped-diamond jewel is readily apparent.

It may be objected that not yet has it been shown that the estimated expense for meter testing is warrantable. The reply in the first place is that any reasonable expense is warrantable which will make a company's bills accurate and its dealings with its customers honest. In the second place, the expense will be in all probability more than met by the increased revenues from accurate meters. This statement is difficult of demonstration as we are unable to know just what the accuracy of the meters is under working conditions, either with or without testing, but we will give two illustrations which will hardly leave any doubt as to its truth.

About two years ago the Chicago Edison Company changed from a system of annual testing, with semi-annual testing of a few of the largest meters, to the classified system outlined in this paper. Under the old system the meters ran from fifteen to sixteen months between tests owing to interruptions in the work and changes of inspectors. After the change sufficient help was employed to keep the work strictly up to the schedule. As a result of this testing the unaccounted-for output decreased from 8.7 per cent. to 7.1 per cent. of the total generated, showing a saving of 1.6 per cent. As the generated output for the year was 76,454,000 kilowatt-hours the saving amounted to 1,223,264 kilowatt-hours. This represents additional energy paid for, so to determine the income saved to the company it must be multiplied by the average price received. Assuming this to be seven cents per kilowatt-hour, we find the saving amounted to over $85,000. This is sixty per cent. more than the total meter department expense, about three times the total expense for testing and repairing meters, and eight times the additional expense over that previously expended for testing.

Take another example. In a suburb near Chicago the meters had been allowed to run much as they pleased for several years. A year ago they were all overhauled and some of the old types discarded. Last fall the income showed an increase of thirty-eight per cent. over the previous year and one-half of this increase was attributed by the manager to the improved accuracy of the meters.

Meter testing, however, as stated above, is a matter of ethics as well as economy. Suppose your average accuracy is at present so high that the cost of testing will not be covered by the increased income, still it is the duty of lighting companies to take all possible precautions to prevent inaccuracies in their bills. Fortunately the meters manufactured to-day retain their accuracy better than those of a few years ago, and when these older types have all been worn out or discarded it is hoped that less frequent testing will be necessary. Present conditions, however, demand that companies should give more attention to meter testing than is ordinarily done. It is also a fact that those companies which have done the most in this line best appreciate its economic value.

District..................................

DAILY RECORD OF METER TESTS.

Month of..............................190........

....Tests. ....Meters.

Date	Meter Testers	Meters Tested	O. K. on both Loads	HEAVY LOAD TESTS.												LIGHT LOAD TESTS.															Meters Creeping	Defective Jewels	Meters Exchanged
				O. K.	2—5% Fast	5—10% Fast	10—20% Fast	20—30% Fast	....% Fast	2—5% Slow	5—10% Slow	10—20% Slow	20—30% Slow	....% Slow	Stuck	O. K.	2—5% Fast	5—10% Fast	10—20% Fast	20—30% Fast	....% Fast	2—5% Slow	5—10% Slow	10—20% Slow	20—30% Slow	30—40% Slow	40—50% Slow	....% Slow	Stuck	Adj. O. K.			

The Installation and Operation of Alternating Current Generators

Engineers in charge of power stations, as well as students of electrical engineering, will be interested to read the instructions for installing and operating alternating current generators recently prepared by the Allis-Chalmers Company, of Milwaukee, for the use of its customers, which are reproduced in part herewith. What is stated, applies in general to the machines of any manufacturer, and no difficulty will be found in noting what is special practice.—EDITOR.

ALL of the generators belong to the revolving-field class having the armature, or part in which the current is induced, stationary. They are made in five types designed as Belted, Water-Wheel, Engine, Fly-Wheel and Turbo, the last named being for direct-connection to Allis-Chalmers steam turbines.

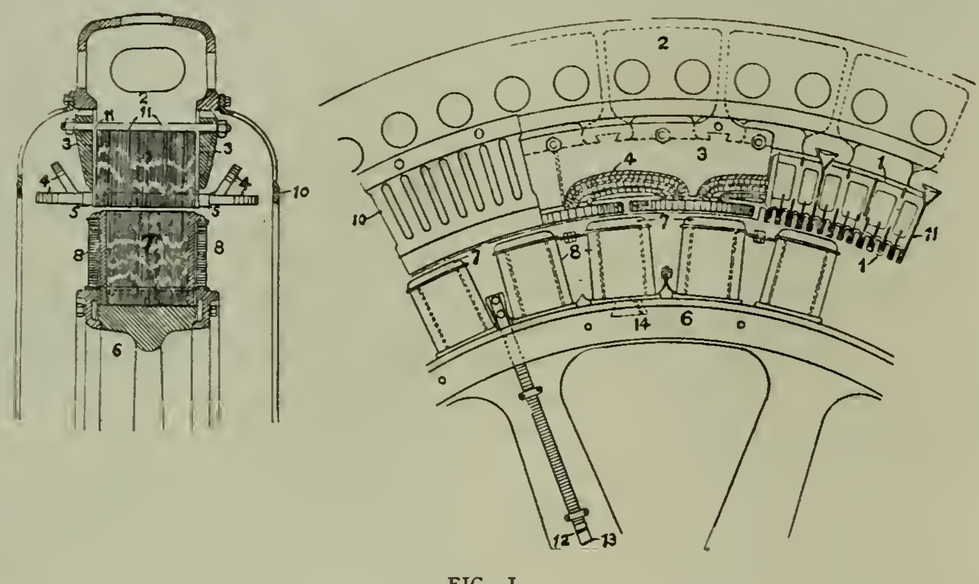


FIG. 1

1 Armature Core
2 Stator Yoke
3 Armature End Head
4 Armature Coil
5 Armature Coil Stick
6 Field Spider
7 Field Pole
8 Field Coil
9 Pole Collar
10 Winding Shield
11 Ventilating Duct
12, 13 Field Connections
14 Pole Keys

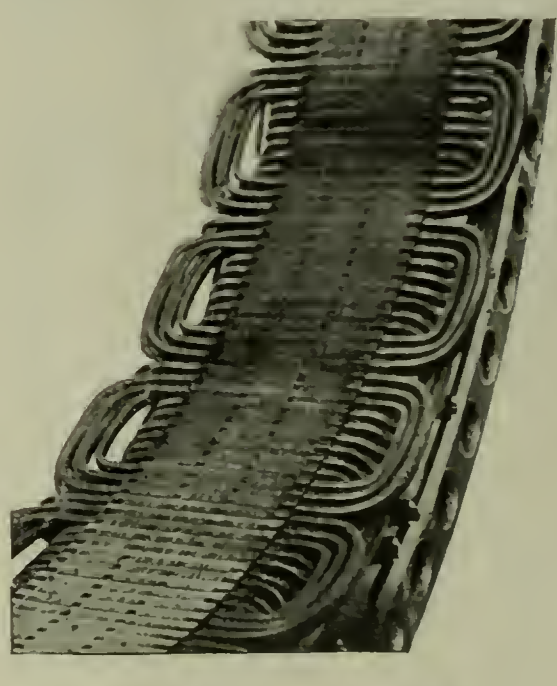


FIG. 2.—MULTIPLE SLOT WINDING.

The mechanical construction varies to some extent with the size and type of generator, so that it is not practicable to give a description that will apply to all these machines. In most cases, however, the general arrangement is as shown in Fig. 1, which explains itself. The method of arranging the coils and interconnecting them varies with the number of phases for which the machine is built, the voltage, etc. Fig. 2 shows a portion of the winding for a three-phase machine with coils arranged the same as in Fig. 1. For lower voltage machines where it is not necessary to have such high insulation, the winding is frequently of the two-layer type shown in Fig. 3. All the coils are of the same shape, and each side occupies only half a slot, one side lying in the upper part of one slot and the other in the lower part of another slot. The field coils of all, except some of the smaller machines are of bare copper strip wound on edge with adjacent turns separated by tough insulating paper. In some small machines it is necessary to wind the field coils with square copper wire in order to admit of excitation at 120 volts.

LOCATION

The location of the generator is usually fixed beforehand by the position it must occupy relative to the engine or shafting. There is, therefore, little choice as to this, but it is always desirable to install alternators, or in fact any electrical machinery, in a clean, dry place where there will be plenty of light and room. Good ventilation is important, since the better the ventilation the lower will be the operating temperatures of the machine. There should not be any combustible material near the alternator and the location should provide for sufficient head room to permit taking the machine apart if necessary.

The foundation on which an alternator rests should be firm and sub-

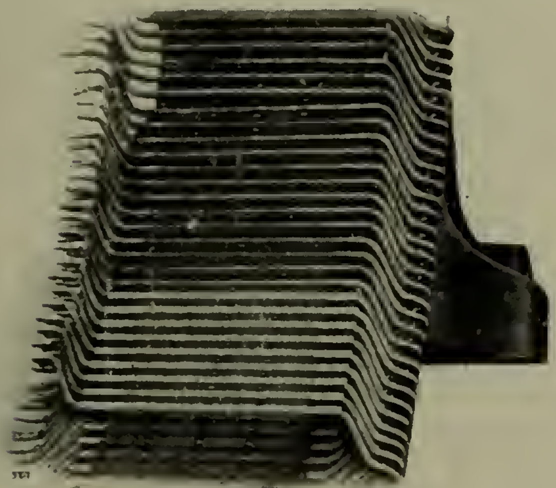


FIG. 3.—TWO-LAYER WINDING

stantial, in order to prevent vibration and secure smooth running. Small belted machines below 100 kw. can, if necessary, be set on heavy timber supports, but it is recommended to use a concrete or brick foundation whenever possible; all machines above 100 kw. must be provided with concrete, brick, or masonry foundation, concrete being the most suitable. Concrete for this purpose can be made in the following proportions: sharp sand, 2 parts; broken stone, 4 to 5 parts; Portland cement, 1 part, all parts by bulk.

The foundation should be heavy enough to secure freedom from vibration and, in building it, provision should be made for foundation bolts to hold the base, rails, or sole plates of the machines. In making the foundation, place iron pipes in the approximate locations that the foundation bolts will occupy, using pipe having an inside diameter of at least two inches larger than the foundation bolts, to allow adjustment. Pockets should also be arranged in the foundation to give access to the anchor plates and bottom nuts on the foundation bolts. After the alternator has been permanently located, thin cement should be run into the pipes, thus fixing the bolts accurately in position. Foundation bolts should be located by templates made from outline prints of the machine. The top of the foundation should be leveled off as accurately as possible and cement allowed sufficient time to set before the machine is placed in position.

The National Board of Fire Underwriters favors the insulation of generators from the ground wherever it is feasible. Such insulation is generally provided by a substantial wooden frame or wooden stringers under the rails, the wood being well filled and varnished to prevent absorption of moisture. This is practicable with small belted generators, but with heavy machines or those direct-connected to steam engines or water-wheels complete insulation from the ground is practically impossible, and it is better to ground the frame positively by means of a heavy copper wire connecting the frame from a water pipe or other convenient ground. In other words, the frame of a machine should either be thoroughly insulated or thoroughly grounded so that there will be no doubt about its condition.

With belted machines static electricity is frequently generated by the belt, thus charging the frame of the machine, if the latter is thoroughly insulated, from ground. This static electricity is generally removed by arranging a comb or series of metal points close under the belt and connecting them to ground. The points can be easily supported on iron pipes as shown in Fig. 4.

The generators must be thoroughly protected against lightning and high potentials due to static electricity. The lines should be equipped with lightning arresters, and in cases where high potential static electricity is liable to accumulate, dischargers should be provided to carry it off.

SETTING UP BELTED MACHINES

a. The rails should be placed in position, approximately leveled, and wedged up so that the weight of the machine will be distributed evenly.

b. If the alternator is small and comes completely assembled, it can now be set on the rails, carefully leveled, and lined up with the driving pulley.

c. If the machine is of large size, and shipped in two or more parts, place the base on the rails and set the stator or armature frame in position, first making sure that the planed surfaces on the base and feet of the stator are perfectly clean and oiled to prevent rust. Most of the larger belted machines are arranged so that the stator can be shifted to one side to give access to the field and armature coils, and when the stator is first set on the case it is advisable to locate it so that it will be to one side of the field when the latter is placed in position. All bearing surfaces should be thoroughly cleaned before the shaft is placed in the bearings; if there are any rough or rusty spots on the journals, they should be removed with crocus cloth; see that the oil wells are thoroughly clean. When placing the rotor in position, watch the oil rings carefully to see that they do not get jammed and bent out of shape; after the rotor has been placed put the caps of the bearing pedestals in position and bolt down firmly. The stator can now be slid into position over the rotor and bolted in place; if there are any dowel pins in the feet of the stator, see that they are in place before the cap bolts are screwed down. Fill the bearings with a good quality of mineral oil to the proper height as indicated by the oil gauge.

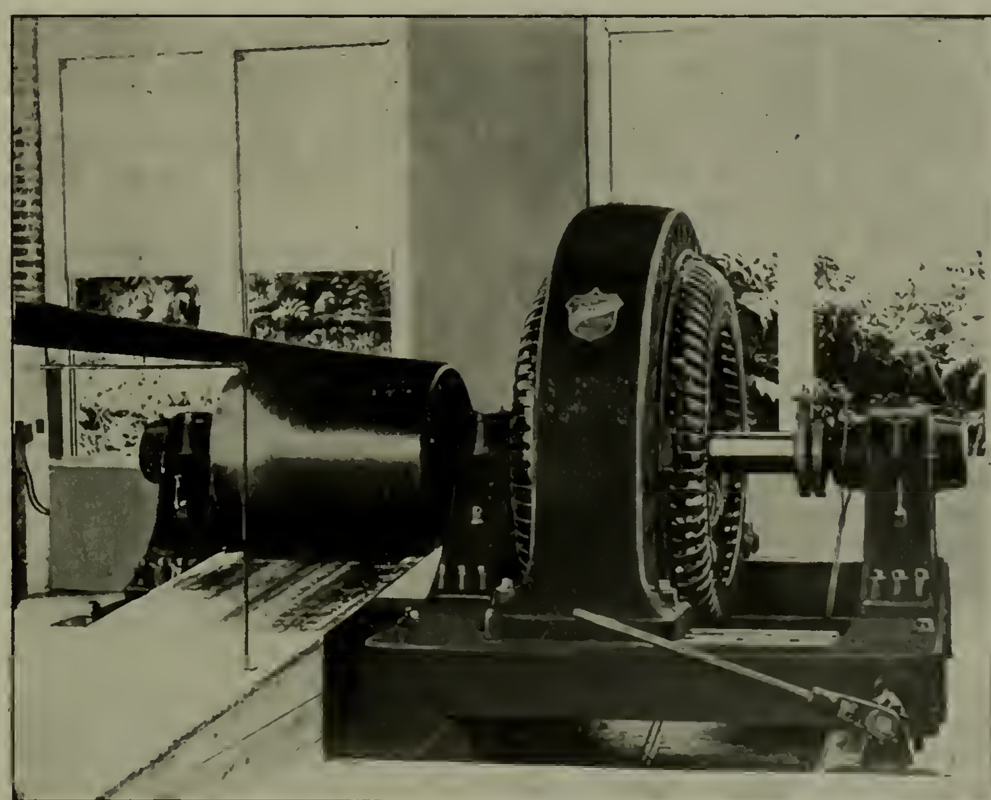


FIG. 4.—BELTED ALTERNATOR, SHOWING STATIC COMB UNDER BELT

d. Put the pulley on the shaft, and line the whole machine up with the driving pulley. If possible, run the machine with a rather slack belt and adjust the alignment while running so that the belt runs on the center of the pulley and allows the rotor to oscillate freely in its bearings.

e. Tighten down the foundation bolts and "grout" the rails by making a thin, easy-flowing mixture of one part of Portland cement and one part of sand together with sufficient water, and pouring it under and around the rails; small clay dams can be used to keep the thin cement in place until it hardens. When the cement is partly set the surplus can be removed and the joint under the rails smoothed up.

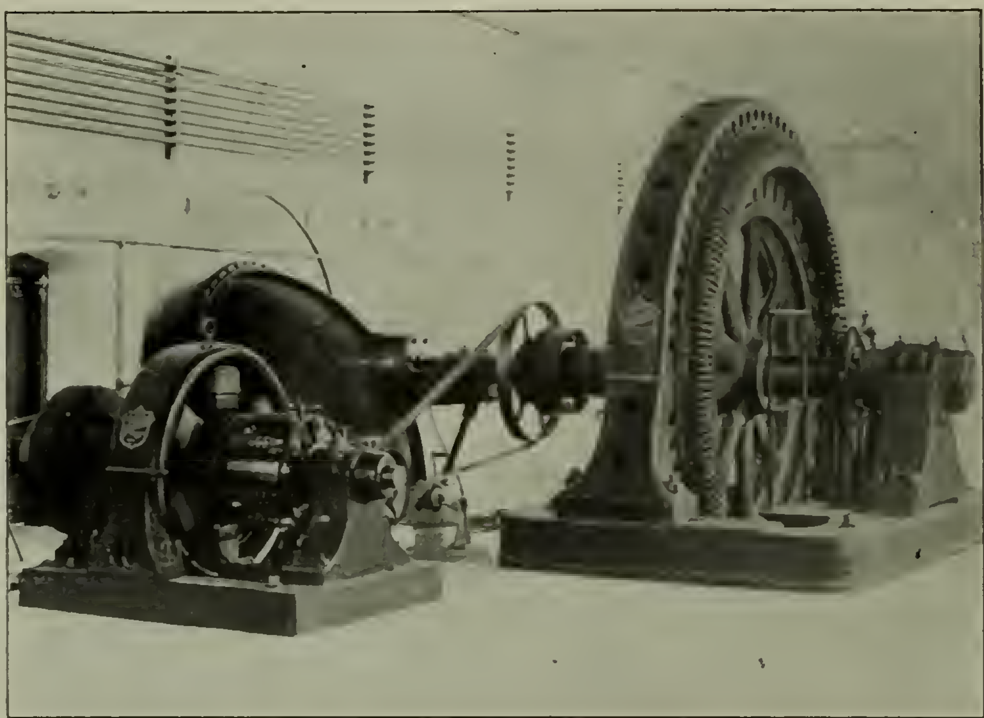


FIG. 5.—WATER-WHEEL TYPE OF ALTERNATOR.

WATER-WHEEL TYPE MACHINES

The foregoing directions regarding belted machines apply for the most part to water-wheel alternators also, except that the latter have no rails, and the base is set directly on the foundation. In this case the machine must be lined up accurately with reference to the water-wheel so that the halves of the flange coupling will fit exactly. After lining up by means of wedges under the base, the foundation bolts should be tightened and the base well grouted in. Use plenty of wedges, and place them under both inside and outside edges of the base so as to give a firm and even support. In some cases where the water-wheel alternators are of large diameter and run at low speed, no base is provided. The stator and bearing pedestals rest on sole plates bolted to the foundation in the same manner as described below on engine-type alternators.

ENGINE TYPE MACHINES

With engine-type alternators the stator yoke either rests on an extension of the engine bed, as with some of the smaller machines coupled to high-speed engines, or on sole plates set on suitable foundations. The stator sole plates are made in two parts, the lower one being bolted to the foundation, while the upper plate is adjustable to facilitate centering the stator with respect to the field.

a. Locate the sole plates temporarily in position and support them on iron wedges to allow for further adjustment.

b. Place the lower half of the stator in position and level it approximately by means of the leveling screws in the upper part of the sole plate. In case the stator is arranged to shift sideways on the base or sole plates, set the stator to one side so that it will be away from the rotor when the latter is placed in position.

c. Locate revolving field and engine shaft in bearing, observing the same precautions as given under belted machines.

d. Place the top half of the yoke in position, first making sure that all planed surfaces are perfectly clean. Carefully center the stator with respect to the field by means of the adjusting screws in the feet and sole plates, and measure the air-gap between stator face and pole piece at a number of points around the circumference; it is very important to have the air-gap uniform, as otherwise the frame will be subjected to an unbalanced magnetic pull, causing bad operation.

In large water-wheel and engine-type alternators, where the stator is split, it is usually necessary for convenience in shipping to disconnect and remove a few of the stator coils at the two partings in the frame. These must be carefully put in place and properly connected as per instructions furnished with the generator. The coils must not be bruised, and all connections should be neatly made and insulated to correspond with those for the other coils.

In aligning the yoke, see that the center of the armature laminations is in line with the center of the pole laminations; if they are not in line there will be a side thrust on the shaft.

After the yoke has been finally adjusted insert shims between the upper and lower parts of sole plates so as to take the weight off the leveling screws. Drill and tap holes in the lower sole-plate to receive the holding-down bolts for the stator, and bolt the latter securely in place. Fig. 7 shows the construction of adjustable sole-plates. *A* is the lower plate bolted to the foundation, and *B* is the upper adjustable plate; *CC* are the

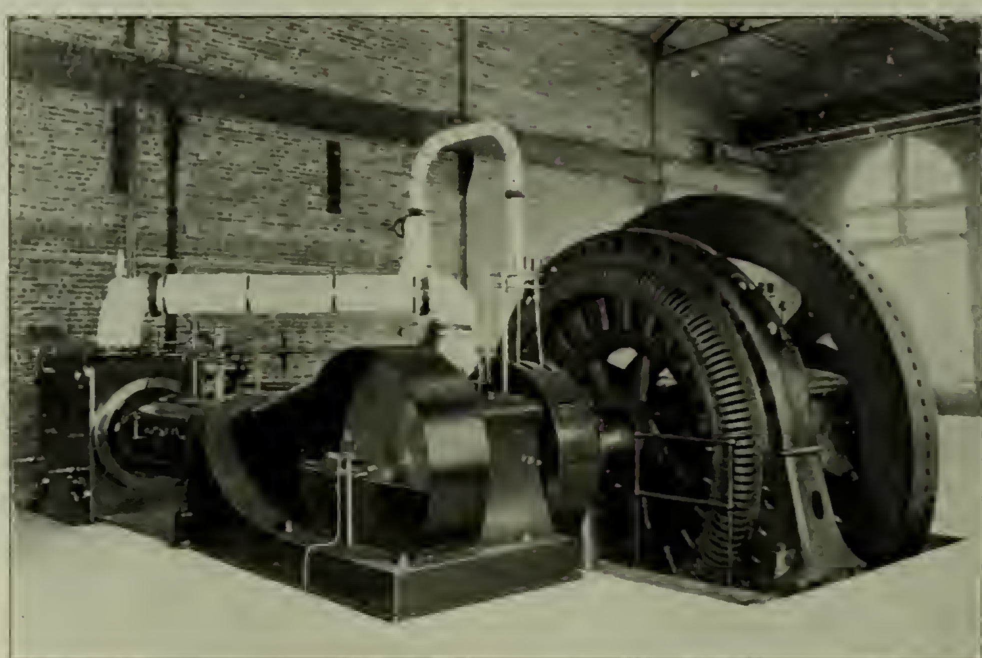


FIG. 6.—ENGINE-TYPE ALTERNATOR.

leveling screws. The yoke is held in line by spline *E*, and by means of a bolt threaded into block *F* the yoke can be shifted in a direction at right angles to the shaft. For sliding the yoke sideways along the sole-plate a jack screw *H* turns in nut *K* and bears against a plug *M* that fits into a hole in that stator foot. Parts *H, K* and *M* are removed after the stator has been shifted to its final position.

e. Grout in the sole-plates, and after the cement has set, tighten the foundation bolts and carefully check over the alignment of the machine.

If at any time the engine bearings are adjusted or realigned, the air-gap between stator and rotor must also be checked over and the stator lined up, otherwise an uneven air-gap will result or the rotor may even rub on the stator.

COLLECTOR RINGS

With small alternators the collector rings are mounted in place on the shaft and connected to the field windings. On large machines, especially engine-type where there is no shaft, the rings are shipped separately, and in large machines both hub and rings are split so that they can be put in place after the rotor has been mounted in its bearings. See that the collector rings are fixed securely in position so as to run true, and connect rings to leads from the field winding, making sure that all contacts are clean and bolted up tight.

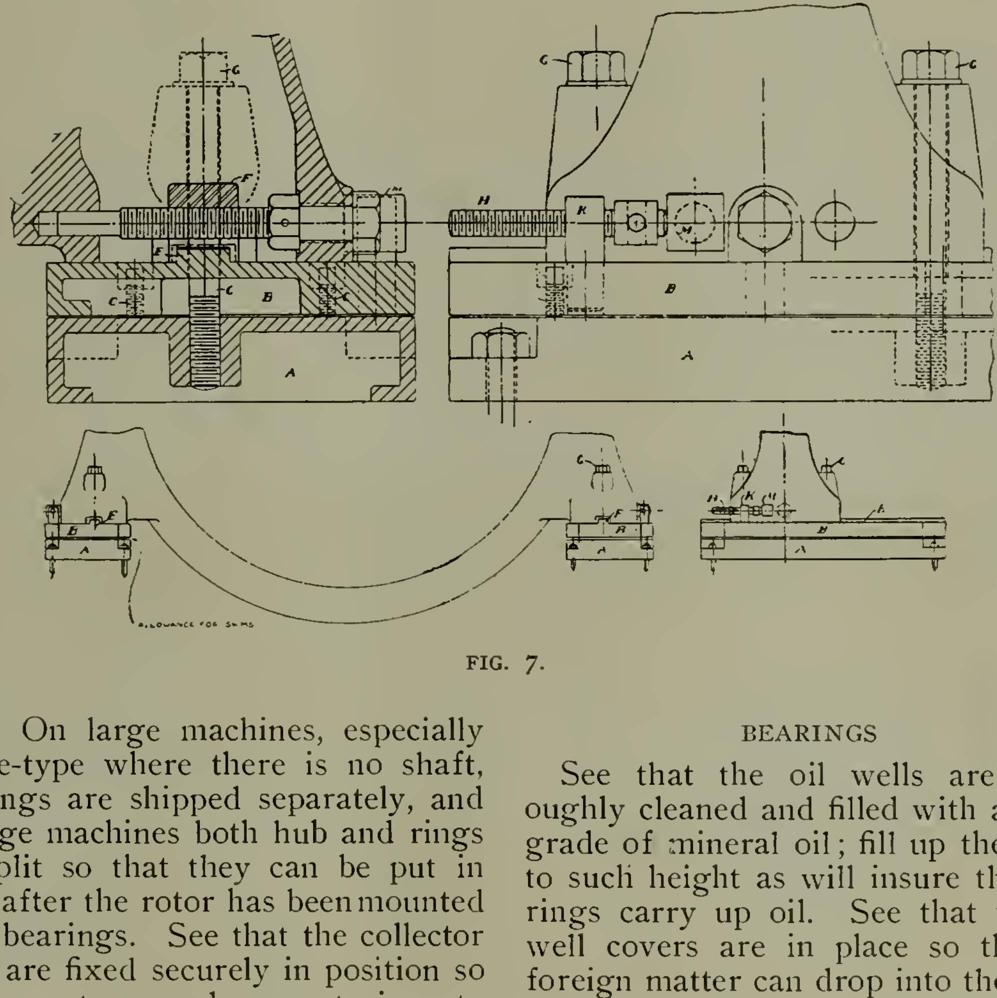


FIG. 7.

With large engine-type alternators, and also with some of the larger water-wheel machines, the brush holders are supported by a stand bolted to the vase or to a bridge fastened to the sole plates. On smaller machines the brush-holder studs are supported by the bearing pedestal. See that all insulating bushings and washers on the brush studs are in place and that the studs are bolted up tight; also that the brush-holder stand, if any, is firmly bolted to the bed or bridge, and that it is properly lined up with the collector rings.

BRUSHES

The brushes should be carefully fitted to the collector rings, first using coarse sand or garnet paper and finishing with fine sand-paper. While shaping the brushes hold the paper well down on the rings so as not to wear away the edge of the brush. See that the whole surface of the brush makes contact with the ring, and that the finger presses squarely on the brush. The pressure should be adjusted by changing the position of the tension spring on the arm, and should be such as to give a good contact on the ring; a greater pressure improves the contact very little and only causes excessive friction loss, wear and heating of the brushes and rings. Good judgment and careful attention will soon show the best pressure to use.

BEARINGS

See that the oil wells are thoroughly cleaned and filled with a good grade of mineral oil; fill up the wells to such height as will insure that the rings carry up oil. See that the oil well covers are in place so that no foreign matter can drop into the bearings. When the machine is first started it is advisable to draw off the oil at the end of each day's run and fill up with fresh oil until it is certain that all fine particles of foreign matter are out of the bearings. The oil drawn off can be filtered and used over again. When a machine is first started, it is advisable to run slow for an hour and watch the bearings closely before running up to full speed.

WIRING

In all wiring, special attention must be paid to the mechanical execution of the work and special precautions are necessary with the wiring for high-pressure alternators. In running the wires the requirements of the National Board of Fire Underwriters should be observed, and special care should be taken to have all joints secure and thoroughly insulated. All wires should be of sufficient cross section to carry at least 25 per cent. overload without overheating. For wires larger than No. 2 B. & S., it is advisable to use stranded cable, as it is much easier to run than solid wire.

DRYING OUT

If a machine has been exposed to low temperature, it should not be unpacked until it has reached the same temperature as that of the room, otherwise a film of moisture may form thereon due to condensation. After the alternator has been set up it should be dried out by short-circuiting the armature terminals and running the machine with low field excitation sufficient to circulate in the armature a current about 25 per cent. greater than normal full load current. An ammeter should be inserted to indicate the current, and the machine run until it has become thoroughly warmed up and all moisture expelled.

STARTING UP

In case the alternator does not operate in parallel with other machines the following instructions should be observed:

Bring the alternator and exciter up to speed and make sure that the oil rings are revolving freely. See that all resistance in both exciter and alternator field rheostats is cut in and that both field and main switches are open. Cut out resistance in exciter field and bring the exciter voltage up to normal. Close the field switch of the alternator, and have all resistance in so that full voltage will not be generated in the windings. In case the machine is being started for the first time, allow it to run for an hour or two at low voltage and then gradually increase the voltage until it reaches normal; the load can then be thrown on. As the load increases it will be necessary to cut out some resistance in the field circuit in order to maintain full voltage, and if the load on the alternator is inductive a larger amount of resistance must be cut out than with non-inductive load. On light loads comparatively small field excitation is required, and it is advisable to run the exciter at rather low voltage and avoid wasting so much power in the field rheostat, provided the exciter voltage is not made low enough to render the operation unstable or cause sparking at the brushes, and that the exciter is not used for exciting other alternators.

SHUTTING DOWN

Where a machine is run by itself and is to be shut down, first cut in resistance in field of alternator, thus

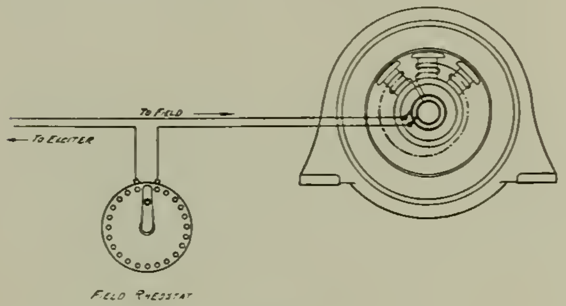


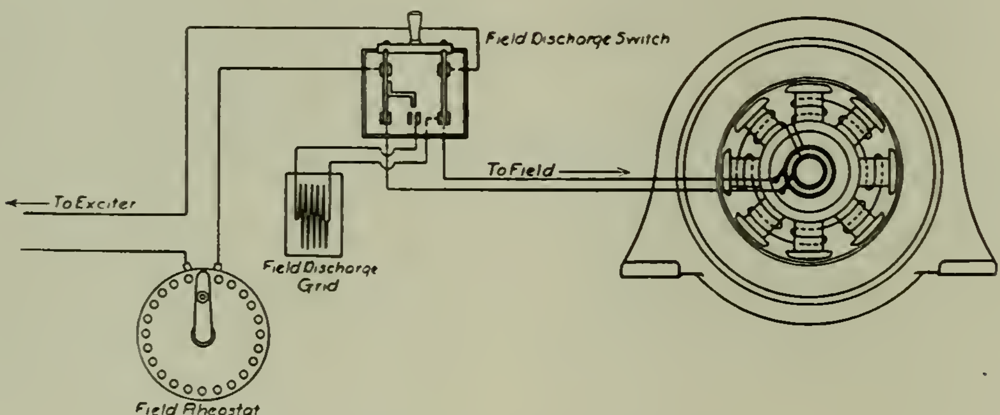
FIG. 8.

lowering the voltage. Then open the main switch and finally the field switch of the alternator. The alternator field circuit should not be opened when full current is flowing because the high induced e.m.f. caused thereby may be sufficient to break down the field insulation. With most of our larger machines a grid resistance is connected to the field switch so that in case the latter is opened the resistance is first connected across the field circuit, thus forming a path through which the induced current can flow and prevent any abnormal rise in e.m.f. Fig. 8 shows exciter connections for small machines, and Fig. 9 for larger alternators where a grid discharge resistance is used.

PARALLEL OPERATION

When two or more alternators are run in parallel there are certain conditions that must be met in order to secure satisfactory operation. These are:

a. The machines must be in synchronism. That is, the frequency



Exciter Connections With Field Discharge Resistance

FIG. 9.

must be the same for each, and the e.m.f.'s of the different machines must be in phase.

b. The e.m.f.'s must be approximately equal.

c. In order to secure proper division of the load under changes in load conditions, the speed regulation of the prime movers must be alike.

d. To prevent periodic cross currents between machines, the variations in angular velocity of the prime movers must be kept within certain limits. In water-wheel or steam-turbine driven units the angular velocity is uniform, but with reciprocating engine units there may be trouble due to periodic variation if the engine flywheels are not heavy enough.

BELTED ALTERNATORS

With belted alternators it is very important that the pulleys be proportioned so as to make the speeds of the alternators such that they will give exactly the same frequency; if all the machines have the same number of poles their speeds must be exactly alike. If the pulleys are not of the proper size there will be excessive belt slippage or exchange of cross currents between the machines, thus causing fluctuations in voltage.

ENGINE-DRIVEN ALTERNATORS

With engine-driven alternators the speed can be varied by adjusting the governor, and there will be no trouble from cross currents provided the angular velocity of the engines does not vary too much, and the engine governors act properly.

DIVISION OF LOAD

When two alternators are running in parallel their output (actual power) depends on the amount of power supplied by their prime movers. For example, suppose two engine-driven machines are running in parallel on a certain load, and that each is taking half of the load. When the load increases there is a tendency for the speed to drop slightly, and in order for the engine governors to act and admit more steam, there must be a slight drop in speed. Now the two alternators must always run in synchronism, or at the same speed, assuming the number of poles to be alike, and if the drop in speed does not result in an equal increase in the steam admission of each engine, one alternator will be supplied with more power than the other and the load will become unequally divided. Changing the field excitation of the lightly loaded machine will not remedy matters (as with direct current generators where the generators do not have to run in synchronism and have independent speeds). The only effect of changing the field excitation is to make a wattless current circulate between the two alternators, the actual amount of power supplied by each remaining the same. The only way to increase the steam admission is by adjusting the engine governor, and to

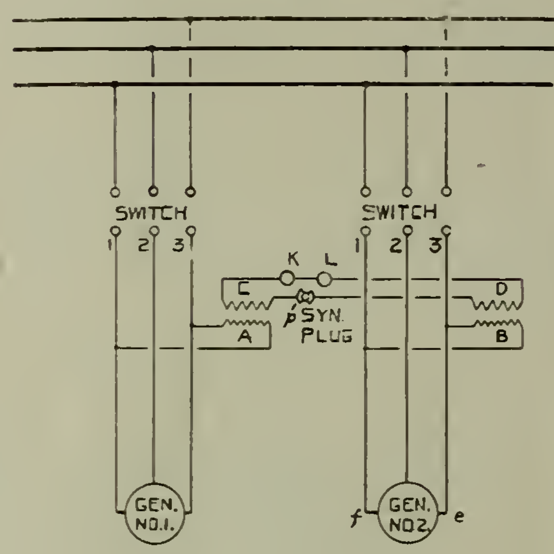


FIG. 10.

secure equal division of load under all conditions the change in speed for a given change in load must be alike for each engine. When two or more alternators are run in parallel, it is advisable to have an indicating wattmeter on each machine, so that the actual load will be indicated. In case wattmeters are not provided the load on each should be adjusted so that the sum of the currents as indicated by the machine ammeters will be a minimum for a given total current supplied to the line. If the sum of the machine currents is much in excess of the line current it shows that a wattless current is circulating between the machines.

SYNCHRONIZING

The condition of synchronism is usually indicated either by incandescent lamps, or by a synchronism indicator or synchroscope, the latter now being used in most large installations. A synchroscope gives more accurate indications than lamps, and has the additional advantage of showing whether the incoming machine is coming into or going out of phase and how much it is out of phase.

Fig. 10 shows diagrammatically the connections for synchronizing lamps. Two small transformers, *A* and *B*, have their primaries connected to the same phase of each generator. The secondaries, *C* and *D*, are connected in series through a plug or switch *p*, and lamps *KL*. Assuming that corresponding terminals of the primaries are connected to corresponding lines on each machine, and that the two transformers are alike in every particular, corresponding secondary terminals will, at any given instant, have the same polarity when the two machines are in phase. When plug *p* is inserted, secondary terminals of opposite polarity are connected together; hence the two secondary e.m.f.'s are in series and aid each other in forcing current through lamps *KL*, which are, therefore, bright at synchronism. It may happen that the transformers are not wound exactly alike or that the connections have become confused; it is always advisable, therefore, to test the connections to make sure that the lamps are light or dark at synchronism. To test the connections in Fig. 10, disconnect *B* from Gen. No. 2, and transfer the connections, without changing their relative position, to lines 1 and 3 of Gen. No. 1; *A* and *B* will then be connected to the same lines, and if the lamps are bright, they will also be bright at synchronism where *B* is connected to Gen. No. 2, as shown. If dark lamps are preferred, either the primary or secondary connections of one transformer may be reversed.

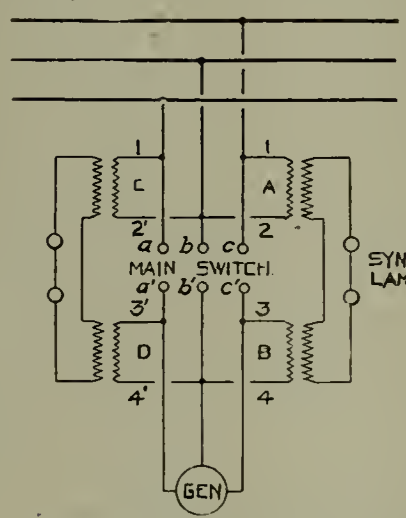


FIG. 11.

Another method of testing the connections is to leave the transformer connections as they are and disconnect the main leads *e f* on Gen. No. 2. Both main generator switches are then closed, thus connecting both transformers *A* and *B* to Gen. No. 1. In synchronizing, bright lamps are to be preferred to dark.

When a polyphase alternator is first connected up it is important to see that all of its phases correspond with those of the bus-bars; if one phase only of a three-phase machine is correct, it does not follow that the other two are correct also. Two of the phases should be tested at the same time by using a pair of auxiliary transformers in addition to the regular synchronizing transformers *AB*, Fig. 11. Transformer *A* is connected to the bus-bars and *B* to the generator. A second pair of transformers *CD* is connected to one of the other phases, the connections in each case being such that the lamps are bright at synchronism. The connections should be tested as described above to make sure that the polarity of the transformers is correct. With the main switch open and with the generator running at full voltage, both sets of synchronizing lamps should pulsate together. If they do not do so the leads from the generator are incorrectly connected to the generator terminals and should be interchanged so as to make the lamps pulsate together. After this test has been made, to insure that terminals *a, b, c* connected to the bus-bars correspond to *a', b', c'* connected to the generator, the temporary transformers *CD* can be removed.

BELTED MACHINES

When a belted alternator is to be thrown in parallel with another machine, first bring the incoming generator up to speed and adjust the voltage until it is approximately the same as that of the bus-bars. Adjust the speed until the beats of the synchronizing lamps become very slow, say one beat in two or three seconds, or until the pointer of the synchroscope is moving very slowly. Close the main switch when the lamps indicate synchronism (lights light or dark depending on the connections), or when the pointer of the synchroscope is over the central point or slightly ahead of it. Adjust the field excitation and see that the alternator is supplied with enough power to make it carry its share of the load. In case a number of belted alternators are driven from a common line shaft, the belt of the incoming machine should be slackened, thus introducing enough slip to allow the machine to be synchronized. After the alternator is in step the belt can be tightened and the load gradually applied.

ENGINE-DRIVEN MACHINES

With engine-driven alternators the incoming machine should be given only a small amount of steam until after it is synchronized. The load can then be taken up by admitting more steam. In large plants the engine governor is usually arranged so that it can be controlled electrically from the switchboard, and the steam admission varied as desired. If the governor cannot be so controlled the steam admission can be regulated at the throttle. Water-wheel governors are also frequently provided with an electrical control device; if not, the gate opening must be controlled by hand to synchronize the machine and adjust the load.

SHUTTING DOWN

When machines are operated in parallel, and one is to be shut down, first reduce the load by throttling the engine or slackening the belt. Then open the main switch. Cut in resistance in field of alternator to reduce field current, and open field switch.

GENERAL CARE OF MACHINE

On account of not having a commutator, alternators are, on the whole, much easier to keep in good running order than direct-current machines. At the same time they must be properly attended to. It must be remembered that they frequently generate much higher pressure than direct-current machines and there is all the more necessity for keeping them perfectly clean. No dirt, copper or carbon dust should be allowed to accumulate on or near the windings, and in plants sufficiently large to warrant the expense, it is advisable to install a compressed air system so that all dirt can be blown out of the corners not otherwise easily reached. It is also advisable to give the armature coils and connections a coat of insulating varnish occasionally.

Keep the collector rings lubricated with a small quantity of vaseline applied with a cloth, and see that the brushes make good contact with the rings.

Never open the field current suddenly while current is flowing, and see that both main and field switches are open when the machine is not running.

Never throw machines in parallel when they are out of synchronism, the excessive rush of current throws heavy strains on the engines and generators and may cause considerable damage.

Remember that the alternators are designed for the voltage indicated on the name-plate. They must not be expected to give voltages considerably above normal with satisfactory performance of either exciter or alternator. This point is here mentioned because frequent attempts to raise the voltage an excessive amount have resulted in poor operation through no fault of either exciter or alternator. Furthermore, the rated current output should not be continuously exceeded.

See that all bolts and nuts are kept tight. Electrical machinery should receive as much attention in this respect as steam engines.

Niagara Power at the Lackawanna Steel Plant

JOHN C. PARKER

NOTE—The description of the engineering conditions which led to the use of Niagara power at the plant of the Lackawanna Steel Company and the various notes on the methods of transforming and distributing this power are taken by permission from a recent issue of *The Electric Journal*, which enjoyed exceptional opportunities in getting the data. It is reprinted here, since it is an out-of-the-usual engineering article, and is replete with valuable suggestions.—EDITOR.

A FEW years ago the West Seneca works of the Lackawanna Steel Company were established. At these works electrical energy is used for many of the incidental processes. Owing to the large size of the gas engines, and the extent of the installation, considerable attention was attracted to the equipment for utilizing blast furnace gases for the generation of power. This gas engine plant was installed for the purpose of operating motors at various points in the plant, these being used for large cranes, gantries, unloaders, conveyors, etc., for the operation of a trolley system, and for the operation of roll tables in the mills. The load is of a decidedly fluctuating character on account of the frequent starts and stops, and the concentrated character of the loading. The load factor, however, is very good as compared with that of a railway or lighting plant.

The utilization of the blast furnace gases necessitated the concentration of the power generating equipment in one point, so that, with the extension of the plant, considerable losses have become inevitable in transmitting the power at the present low voltages of 250 volts direct current and 440 volts alternating current. To adopt a distributed generating system would involve the abandonment of the gas engine as a prime mover. On the other hand, if the concentrated system were to be retained, extensive and more or less unsatisfactory step-up apparatus would be necessary to cut down the losses in the alternating current network, entailing a remodeling of the cable system to accommodate the higher voltage. Nothing whatever could be done to remedy the extensive loss in the direct-current distribution, unless inverted rotary converters were made use of at the power house and corresponding converters at the point of utilization, an arrangement which possesses manifest disadvantages and would be tremendously costly.

As the steel works have grown, the demand for power has exceeded the present supply of blast furnace gas, so that extension of the local generator plant would have involved the use of coal, which would have been out of the question as a competitor to Niagara Falls power. Some advantage obtains from the fact that the capacity of the Ontario Power Company's generating plant is very large in comparison with the normal demands of any individual customer. This gives assurance against interruption due to disabled generating apparatus and permits the occasional carrying of a great excess over the ordinary loads. An appreciation of these facts has led the Lackawanna Steel Company to contract with the Niagara, Lockport & Ontario Power Company for electrical power, transmitted from the plant of the Ontario Power Company at Niagara Falls, Ontario.

The brief description here given of the installation for transforming and distributing this power in the works of the Lackawanna Steel Company, together with a discussion of the more salient features, it is hoped, may prove of some interest. In any event, the rapid progress of the electrical art makes desirable a frequent comparison of notes regarding methods of design and operation.

The engineers of this work had primarily in mind three features, very usual ones in any engineering installation, namely, reliability and continuity of service; facility of operation and maximum total economy. The paramount importance of reliability in such an enterprise as that of the Lackawanna Steel Company is so obvious as to require no comment. It was felt that reliability could be best attained by the utilization of as absolutely simple and "fool proof" apparatus as could be obtained, and by making all parts of the construction straight-forward, simple and readily accessible at all times. This condition in the design accomplished the other two ends which were desired.

INTERIOR OF TRANSFORMER SUBSTATION.

The new electrical equipment, in general, consists of four stations; the substation containing transformers which step the energy from 60,000 volts to 2200 volts; and three feeder stations, which receive the energy at 2200 volts at as many different points in the plant and there convert it to 440 volts alternating current and 250 volts direct current. It is with the equipment of these stations and the intermediate 2200 volt feeders that the present article is concerned. The 60,000 volt transmission line supplying the plant is a part of the system of the Niagara, Lockport & Ontario Power Company, designed under the engineering direction of Mr. R. D. Mershon.

60,000 VOLT SUBSTATION

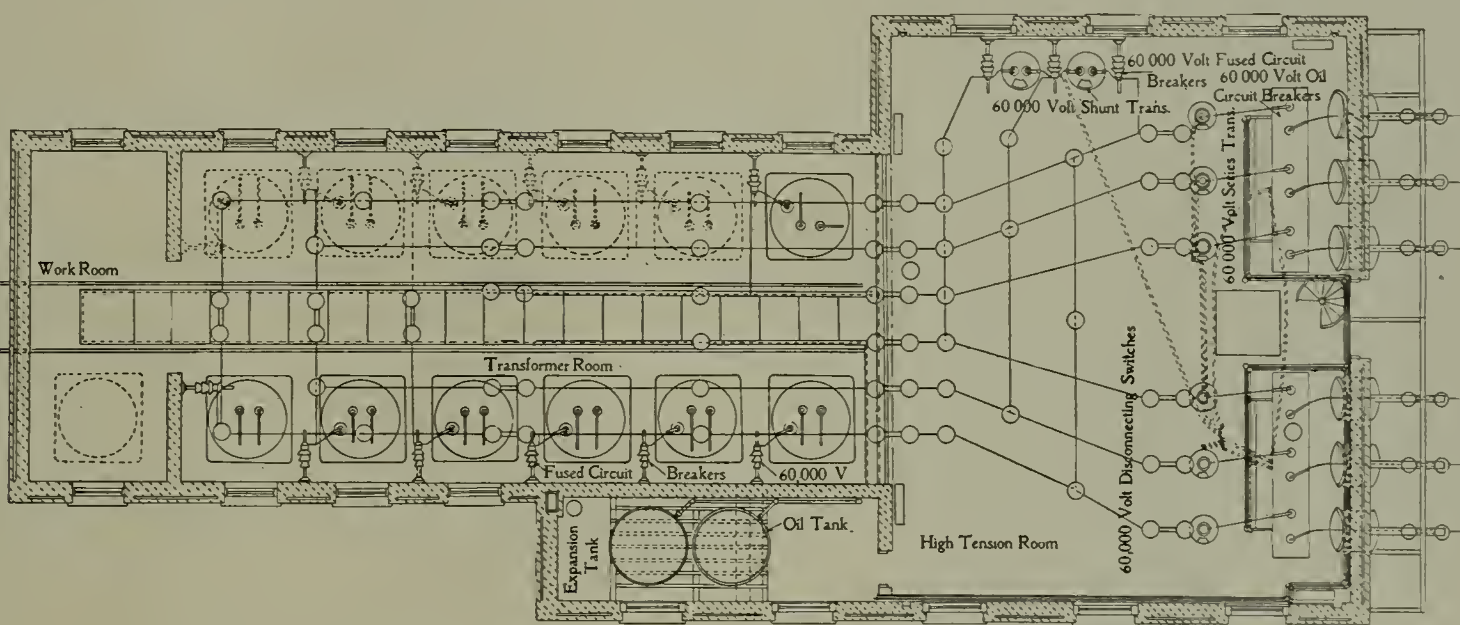
Incoming Lines—Power enters the substation at 60,000 volts through disconnecting switches which may be operated from a balcony on the front of the station building; thence passing inward through oil circuit breakers and series transformers, it is delivered to the station bus-bars which form a loop immediately under the ceiling. These bus-bars are of one-fourth inch copper tubing, supported by standard 60,000 volt line insulators. In the oil switch room a cross-connection is provided so that power may be delivered to either side of the loop from either incoming line. The high voltage bus-bars are sectionalized by inverted knife switches hung from the roof, so that each bank of three transformers may be isolated for changes in the bus-bar system, or for cleaning insulators, if desired.

The Transformers—From the 60,000 volt bus-bars current passes through fused circuit breakers—which act as an auxiliary and selective protection to the various transformer banks, and thence in at the top of the transformers. The transformers are arranged in two rows of six each, and are of 1000 KW. capacity at normal loads and are of the oil-insulated, water-cooled type. Of the ultimate twelve transformers, six only have been installed at present, making two banks with a seventh or spare transformer with means for connecting it into the place of any of the six. The secondaries are wound for 2500 volts with intermediate taps down to 2200 volts, and are delta-connected, the primaries being star-connected, and having the neutral formed by internally grounding one end of each winding to the transformer case, which is in metallic contact with a pair of rails embedded in the building foundations, as well as with the water and oil pipe systems. The transformers rest on I-beams bolted to these rails, and can, by the insertion of steel rollers, be skidded off the I-beams to a small transfer car which runs on tracks in the middle of the transformer room. Two spare transformer stands are provided in a room at the rear end of the station, in which the transformer cases may be assembled, oil dried and tests run. This room is served by a fifteen-ton chainblock hoist supported by a twenty-four inch transverse I-beam immediately under the roof. This arrangement obviates the need for a crane in the building with its attendant objectionable features. The transfer truck may be run out on rails at the rear end of the building and the transformer lifted by means of a railroad yard crane on to the tracks of the plant, so that any part of the transformer may be carried to the machine shop, or elsewhere for repairs.

Transformer Compartments—Careful investigation has proved that it would be practicable to install the transformers without isolating barriers; in fact, that such provisions are not only unnecessary but are positively objectionable because they involve complications in construction and prevent the greatest accessibility. Accordingly the transformers have been placed with no barriers, and with only sufficient space between them to allow proper electrical clearances and safe accessibility for inspection.

Transformer Oil Systems—A similar investigation has led to the abandonment of the more complicated fire quenching and oil emptying systems which have been quite commonly employed of late. The recorded facts in regard to transformer difficulties seem to bear out the theory that these transformers are about as good a fire risk as can be had when placed in a building of fire resisting construction and containing no large quantity of combustibles. The small quantity of air in the transformer cases and the difficulty of igniting insulating oil renders impossible the development of any high pressures, and improbable the ignition of oil vapors. Of course a protracted short-circuit occurring simultaneously with non-operation of the fused circuit breakers and of the oil circuit breakers would result in the building up of internal pressure, due to the boiling of the oil, a condition which is a very remote extremity. To guard against any possible difficulty from such excessive internal pressure, the transformer cases have been vented at the top to two and one-half inch pipes leading both to the roof and to the sewer system, and each vent is provided with a check valve for the exclusion of moisture, as well as for the prevention of the communication of difficulties from transformer to transformer. This system gives all desirable safety and prevents the liability to accident due to the excessively complicated systems of piping involved in sewer drains and flushing connections.

In recognition of the desirability of being able to periodically cleanse and dry the oil used in the transformers and, at the same time, to empty and refill transformer cases rapidly in the event of accident, a system has been adopted which combines gravity



TRANSFORMER AND HIGH-TENSION ROOMS.

emptying and gravity filling with a filtration and drying of the oil in passage from the submerged storage tank for impure oil to the elevated storage tank for clean oil. Entirely separate lines of piping are carried through a central trench in the building for the purpose of carrying oil to, and away from, the transformers so as to prevent the trapping of impure oil which would be washed back by the clean oil in refilling if a single line was used. The filling and emptying pipes are two and one-half inches in diameter, and of short run so that the gravity head can fill a transformer tank in a very short time, much shorter than could be attained with any reasonably small pump, acting directly.

2500 *Volt Wiring and Bus-Bars*—Current passes through cambric-insulated cables from the transformer secondaries along the transformer room walls into the switchboard room, and through oil circuit-breakers, to the station bus-bars. The station bus-bars are at present a simple straight run of one-eighth by three inch copper straps supported on 5000 volt line insulators by studs fastened into the wall. It is expected that the excellence of the insulation will obviate the necessity of a parallel bus, but provision is being made at the present time for extending the present bus all the way round the switchboard room to form a ring, divided into sections by knife switches; thus segregating the various feeders and transformer taps. The present four feeders supplying the steel company's plant will be taken out through oil circuit-breakers to 500,000 c.m. three-phase, 2500 volt cables and thence through an underground conduit system to the various feeder stations.

THE DISTRIBUTING SYSTEM

All secondary current at present delivered to the steel company's plant from the substation will be transmitted to feeder station No. 2, although it is believed that ultimately feeders will be segregated and run to the various centers of activity, their outer ends being connected to form a ring system for the improvement of the load factor on the feeders. Perhaps no part of the installation has been a matter of so careful and anxious thought as this distribution system. The conditions of mechanical operation in the plant are so extremely severe as to render it impossible to do anything in the way of cutting fine the design of the duct system. After numerous studies had been made the engineers of both companies finally settled upon the standard construction of the Lackawanna Steel Company which consists of a group of quadruplex tile duct, carried on pile foundations by reinforced concrete arches of thirty foot span. The arches are necessitated by the extremely light character of the soil found in most parts of the company's grounds which requires extensive piling for almost all structures placed. Any of the more ordinary types of duct construction was prohibited by the liability to fracture, due to the inevitable and indiscriminate placing of heavy stacks of billets, rails, etc., and the running of the railroad tracks through all parts of the plant.

The cable sections have been calculated to meet three conditions: first, when all are in commission and carrying normal load the cables should develop the minimum annual cost for power distribution; second, when one-half of the cables are out of commission for repair, or change, or on account of accident, the voltage drop must not be too large for the operation of synchronous apparatus, or for regulation; third, under these conditions of double normal overload on each cable, overheating of the cables shall not result. These of course are the conditions ordinarily obtaining in such work. As the distance of the transmission is short and the secondary voltage reasonably high, meeting the first condition has fulfilled the other two.

The secondary voltage for the plant was determined by a comparison of the economics resulting from the voltage selected, and from double this voltage. The annual cost of distribution is so low with the conditions chosen that the superior economy resulting from the higher voltage is very small, and although switching apparatus could be a little lighter with higher potentials, operative safety is felt to be sufficiently greater with the voltage chosen to warrant even a considerable sacrifice for the sake of insuring continuity in operation and safety to the operatives.

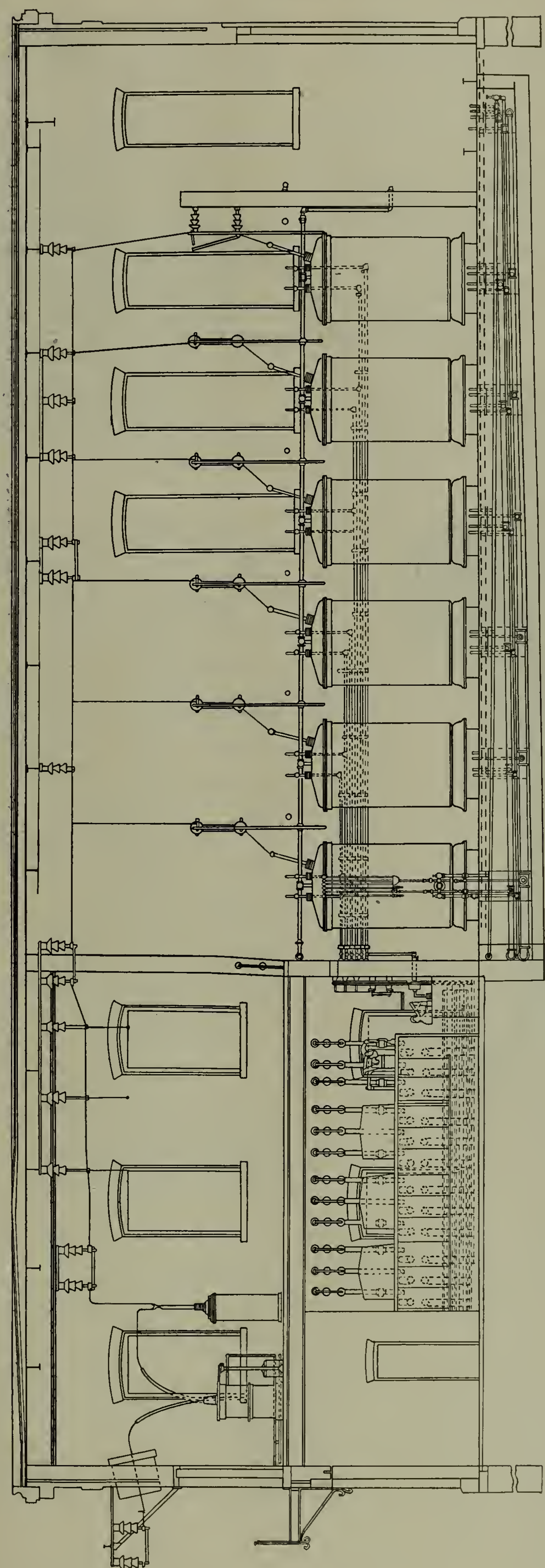
OPERATION

Method of Improving the Power-Factor—The present direct-current load at the steel plant is much in excess of the alternating-current load and the plant load factor is very good. The alternating-current power factor, however, is not very high as the equipment consists of relatively small induction motors, many of them running at only fractional loads most of the time and starting frequently. As the purchaser of power wishes to keep it up to as nearly unity power factor as possible, both for economy in his own conductors and in view of the conditions of purchase, some form of synchronous apparatus was desired to compensate for the lagging alternating-current load. Three methods were suggested: first, the installation of a synchronous condenser; second, the use of rotary converters; third, the use of synchronous motor-generator sets.

Had the first scheme been adopted it would have necessitated the building of a machine with very special characteristics, and the installation of a special switchboard to take care of it, the use of valuable room, and moreover, the very large and unnecessary expense of building a machine specifically for this purpose, whereas by combining load current with wattless leading current in already loaded motors, the same result can be very economically obtained. Moreover, the correction for lagging current would have been felt only at the point where the synchronous converter was placed, and not on other parts of the distribution system so that only one of the objects would have been fully accomplished. On the other hand, this offers the advantage that the substation operator has the control of power factor in his hands rather than having it distributed in the various feeder stations.

Either rotary converters or synchronous motor-generator sets would have attained the end sought for, and it became a question between these two. There is hardly any difference in cost or efficiency between the motor-generator sets taking current directly at 2200 volts and rotary converters with their accompanying transformers. As the 250-volt distributing system of the Lackawanna Steel Company offers a common connection between all the generators in these sets it was desirable to find some means of apportioning the load between various stations so as to keep as high an equipment load factor on the converting apparatus as possible. This could be done by varying the field excitation of converters if sufficient line reactance were present or were introduced, but such an end would be attained only at the sacrifice of phase control. Moreover, it was desired that this end should be accomplished more or less automatically by having the voltage characteristics of the generators rise from 250 to 275 volts at full-load, and then to sharply drop so that the machine would automatically "lie down" on overloads, an end impossible in a well-designed rotary converter.

Equalizing the Load.—As it is desired that the draft of power from the Ontario Power Company's generating plant shall be free from peaks, the Lackawanna Steel Company will operate part of its present equipment in parallel with the transmission line. For this reason, as well as for the equalization of loads on the various machines, it was desired that the volt-



SECTIONAL ELEVATION OF THE SUBSTATION.

age of the converting apparatus should be above the voltage of the original plant of the Lackawanna Steel Company up to a point representing normal load on the former machines, and that the voltage should then drop to a value below that of the old plant, that is, the regulation of the new installation should be purposely made rather poor above a certain value of load. Below this point the Niagara transmission will tend to take all of the load, but no additional load above this point.

If rotaries were used giving a continuous drop of voltage from no-load, the voltage characteristic of the new plant could be made to intersect the more nearly flat voltage characteristic of the present equipment, but such an intersection would be "long" and liable to large displacement due to the variations in the voltage of the transmission line, or of the machines which might be run for the purpose of flattening the peaks. Moreover, such an arrangement would not tend to prevent excessive overload of the individual converters in the immediate vicinity of a concentrated load and would give obviously bad voltage characteristics on the system as a whole. These considerations led to the selection of the present synchronous motor equipment.

This article can scarcely be regarded as complete without an acknowledgment of the kindly and generous assistance received from the engineers of the Westinghouse Electric & Manufacturing Company, who supplied the electrical equipment, and of the ample support given by the officials of the Lackawanna Steel Company—especially should be mentioned Mr. W. A. James, chief engineer of the Lackawanna Steel Company, and Mr. G. M. Sturgass, electrical superintendent. The pleasure of association with these gentlemen has added much to the interest of the development. The architectural treatment of the substation was in the hands of Messrs. Green and Wicks, of Buffalo, who have given an unusually satisfactory appearance to the building. It has been particularly gratifying to note how very good an appearance has been obtained by keeping the design strictly consistent with the purpose to be attained, that is, by a strong and simple treatment of the structural material with absolute freedom from attempts at ornamentation.

Good form restricts the writer from making as complete an acknowledgment as he would like, of the direction and guidance received from his chief, Mr. F. B. H. Paine, under whom, as chief engineer of the Iroquois Construction Company, this work was carried out.

The Electric Range

THE illustration shows one of the most complete electric cooking devices designed to meet the requirements of those desiring to have their household entirely conducted by electricity. The electric range contains the following devices:

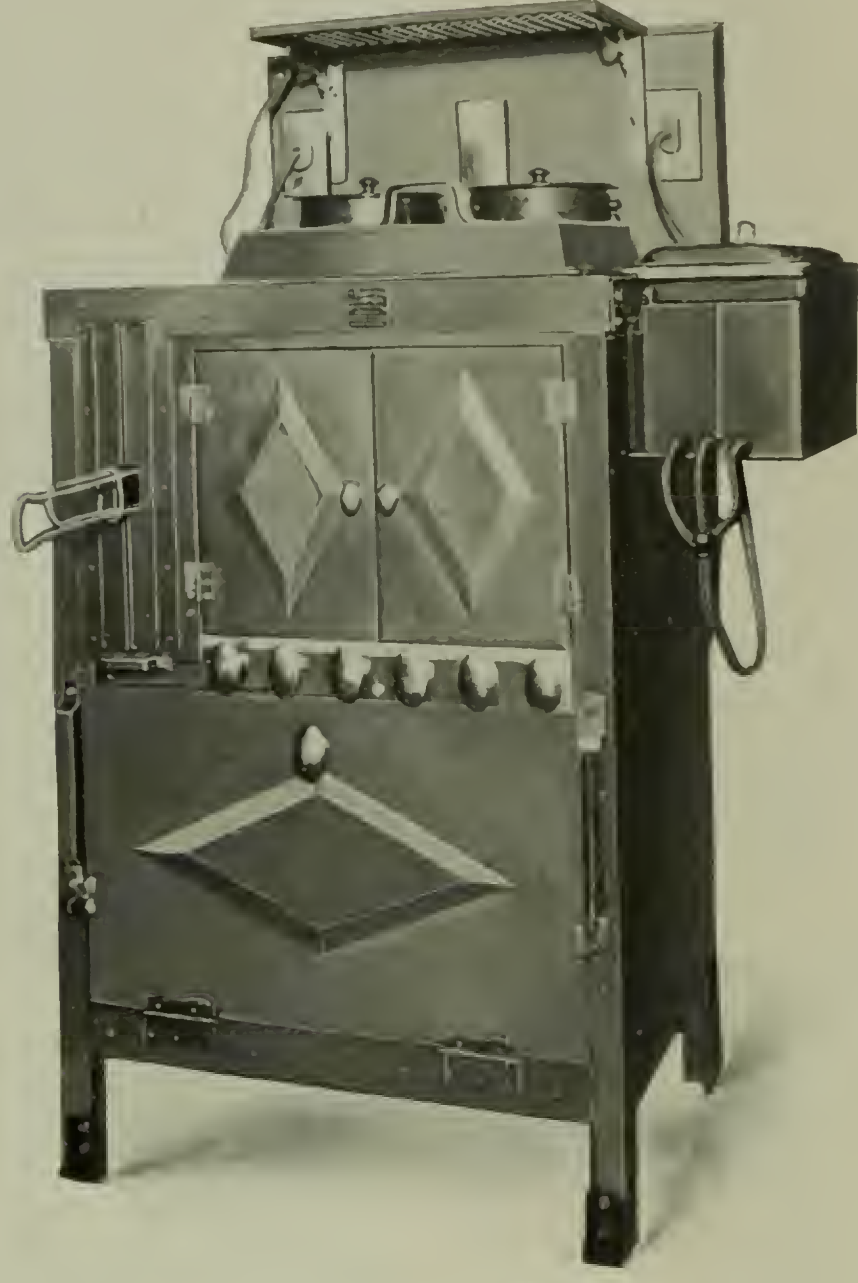
Steam table with two vegetable boilers.

Frying surface (with copper cover).

There is also a small toaster on the top surface of the range along the side of the frying surface, which is not clearly shown in the illustration.

The switches on the back of apparare are given one turn to the right. The slate back has three flush receptacles, one of which is used for the meat boiler. The other two receptacles can be used to operate water boilers, coffee machines or irons, which may be placed on a shelf shown above the slate table. When the meat boiler is not in operation, three devices may be used on this shelf.

The switches on the back of the apparatus can be examined through a small window, which has been set in the back, which closes with a slide.



THE ELECTRIC RANGE.

On the right, there is a copper boiler supported on brackets. This boiler is intended for meats or vegetables, and is connected to the range by a three-terminal attachment cord, which, in turn, connects to a flush receptacle on the slate back.

On the left is a broiler and the plate warming closet.

Below is the oven, for roasting and baking.

The various devices are manipulated by means of switches, operated by the brass knobs which are shown in the illustration, in the middle of the apparatus. To turn the

The apparatus has been subjected to a number of tests and various articles of food were prepared. It was found that all of the devices embodied in the range worked very well. The oven is a good cooker and will roast meat or bake bread or pie in about the same time that it requires to do similar work on a coal range. The heat of the oven, when in operation, will keep the plate warmer hot. In fact, if the oven and broiler are in use, it will hardly ever be necessary to use current for the plate warmer.

It takes about twenty minutes for the broiler to heat up, and then chops were broiled in eight minutes. The frying surface gets sufficiently hot for use in about five minutes. Sufficient water for any cooking can be brought to the boiling point by the steam table in fifteen minutes. As is well known, steaming vegetables is the best mode of cooking them. When all of the devices are in use, the outside of the range does not get very hot, and the surrounding atmosphere therefore remains comparatively cool. There is no chimney connection to the range; it is therefore advisable to place a hood over the range and connect it with a chimney to remove the odors caused by the cooking.

The range shown is made by the Prometheus Electric Company, of New York, who make a number of similar devices.

General Electric Fan Motors

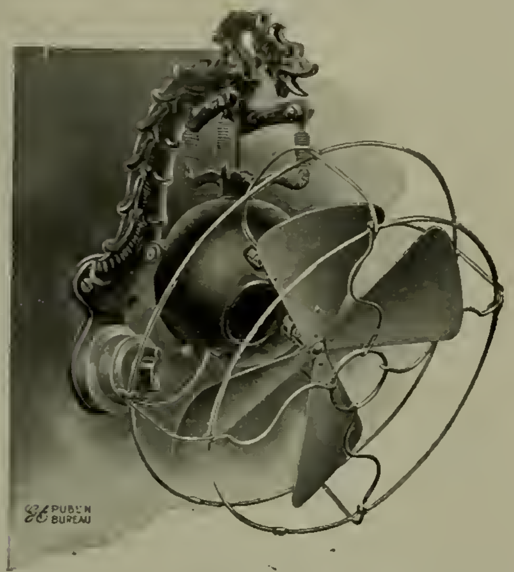
FAN motors have reached a place where they are perennially useful, being available for cooling purposes in summer, and to assist in the heating during the cold weather, as well as to supply air in motion for dozens of other ingenious purposes. When the central station man sells a fan motor to-day, it becomes, after judicious instructions as to its use, a valuable revenue getter.

The General Electric Company makes a complete line of fan motors which can be used as business getters during summer and winter. Desk fan motors are furnished in a number of different types for standard voltages and frequencies, or specially wound to order; and can be obtained with 12-inch or 16-inch fans. These with the bracket type fans are available for all kinds of service.

An odd use of a fan was noticed in a store on a windy street. The customer's entrance to the shop was accompanied by a stiff breeze which disarranged the near-by counters. A large desk fan motor was mounted opposite the door so that it counteracted the force of entering breeze, and the door by this method was opened in a comparative calm.

Combining the compact and efficient design of the desk and wall bracket types of fan motors are the telephone booth ventilating fans and the exhaust fans. The spring suspension of the former eliminates any vibration in the telephone booth and makes what is ordinarily a Turkish bath cabinet more nearly bearable in summer. The General Electric Company makes 8-inch telephone booth fans for both alternating and direct-current.

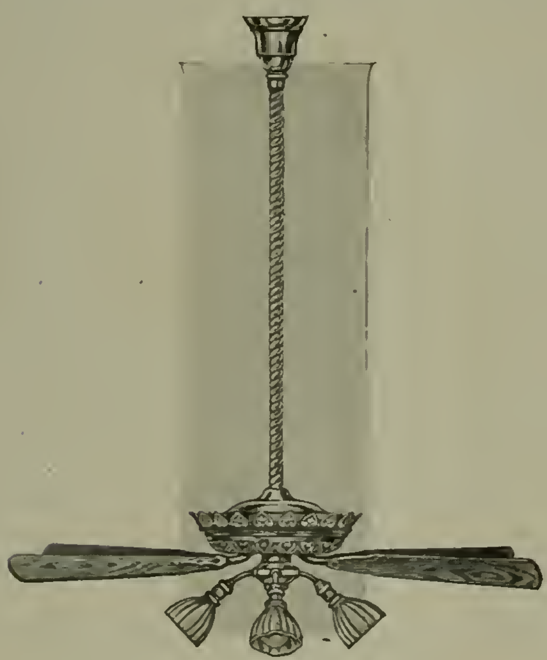
Ceiling types of fans are made; their broad wooden blades suit them especially for the cooling of large areas without disagreeable drafts. The fan blades are 52 inches in diameter for alternating-current fans, and 56 and 58 inches in diameter for the direct-current motors. All have four



TELEPHONE BOOTH FAN MOTOR.

blades and can be obtained in plain or in ornamental designs. The alternating-current ceiling fans have two or three speeds, while the 58-inch blade direct-current fan can be operated at 3 speeds and the 56-inch blade direct-current fan at a single speed. For soda-fountains and restaurants, a combination column fan and electrolier forms a neat fixture, and such a fan is illustrated.

Mention has been made of various speeds of fans. This speed variation



CEILING FAN AND ELECTROLIER.

in alternating current motors is obtained by a six-point reactive coil and switch. In this way the standard desk or wall bracket type is of well-nigh universal application since it may be operated on slow speeds for the office desk or home and on the higher speeds for stores and halls. Similar speed regulation is obtained in the direct-current type of desk and wall bracket fans by a self-contained four-point switch and indestructible resistance, giving three speeds.

Coating Boiler Tubes With Graphite

COATING the inside of boiler tubes with a thin layer of graphite, says "The Electric Railway Review," has given excellent results in a boiler plant using water containing excessive amounts of scale-forming salts. These deposits have required frequent drilling of the tubes. It was found by experience that much less scale adhered to the tubes coated with graphite and that the scale which did form was far more easily removed from them than from uncoated tubes.

The application of graphite might be said to have insulated the steel from deposit and thus rendered the tubes more easily cleaned; and when cleaned their interiors appeared perfectly smooth without the usual patches of scale remaining as is the case after a tube has been bored with a turbine-cleaner. The one application of graphite so adhered to the metal that the interior of the tube had the appearance of a gun barrel, the graphite coat remaining intact after several cleanings. The graphite may be prepared for application to the interior of tubes by mixing it with pure mineral oil in an amount sufficient to form a thick paste, or it may be applied dry.

The Wiring and Illumination of the New Engineering Building

THE unusual requirements to be met in this building make its wiring system of interest to electrical men. The building being for the use of the several societies, in common and individually, made it necessary that the current consumed in different portions should be measured separately. For this reason the feeders were subdivided and the switchboard designed to have a meter on each feeder, in order to permit the making of the proper charges for the current used on each floor; separate feeders being provided for the entrance halls and corridors.

The electric current is supplied from the street mains of the New York Edison Company and the United Electric Light and Power Company. The former supplying direct current from two mains, and the latter 60-cycle alternating current. This duplication of feeders precludes any danger of interruption of the supply of current.

The hall feeders are so arranged that one-third, two-thirds or all of the lights may be controlled from the basement switchboard, in addition local control is possible from cabinets located on the various floors. This makes it possible to closely regulate the amount of current used for this purpose. In the offices it was impossible to plan definitely the arrangements for the various societies, and a molding has been run around the ceiling about eighteen inches from the wall from which drops may be taken off to suit the various desks.

For the auditorium, assembly and lecture rooms special feeders have been run and in addition extra conduits have been provided in order to permit of special service for demonstrations, etc. A special control switchboard is located in back of the auditorium stage, provided with dimmers; and a number of special outlets are located to provide for all of the purposes to which this room will be devoted. The connections of the auditorium feeders are such that single phase, two phase or three phase alternating current and direct current may be supplied.

The main entrance hall or foyer is illuminated by lamps recessed in the ceiling and concealed by ground glass panes, the lamps being distributed to give a good general illumination. In the elevator and side halls the lamps are placed in crystal globes, one or more lamps being used per globe, with suitable reflectors to distribute the light; the globes being designed to reduce the local glare without excessive loss of efficiency.

In the auditorium, at the engineer's suggestion, the architects provided for a space between the ceiling and the floor above, in which the lamps for the general illumination are placed. A translucent glass septem was also used in the ceiling panels instead of plaster. The details in regard to getting at the lamps were also worked out in detail and tests were made in order to secure a suitable glass for the purpose. The result of this care is a very pleasing general illumination without glare. The dimmers provide means whereby the light can be regulated by gradual transitions instead of suddenly flooding the room with light after a stereopticon has been in use, which avoids the unpleasant dazzling of the audience. In the lecture and assembly rooms the cove method of locating the lights was used with pleasing results.

In the library general illumination is provided by means of ceiling lights set in back of a skylight, similar to those used in the auditorium. In addition a number of reading lamps are provided on the reference tables.

Messrs. Hale & Rogers and H. G. Morse, associate, were the architects. The specifications and plans for the electrical equipment, illumination, electrical fixtures, etc., were prepared by Messrs. C. O. Mailloux and C. E. Knox.

Electric Lighting in a Newspaper Plant

THE proper illumination of a newspaper plant is one of the important factors of success in such an enterprise, especially as much of the work must be performed under artificial light. The recently completed plant of the Boston Herald Co., at Boston, Mass., is an excellent example of modern practice in such artificial illumination. The lighting of the large rooms of this plant is accomplished by the use of arc lamps, the installation having been planned by the Illuminating Engineering Department of the General Electric Co. in collaboration with the manager and engineer of the Herald Co.

Newspaper work presents four general classes of illumination: First, business offices; second, reportorial and mailing rooms; third, type-setting and linotype department; fourth, press-room.

The business office demands an ornamental installation capable of producing a strong illumination free from dense shadows. In the case under consideration, this was obtained by the use of the high-current enclosed arc lamp with the recessed type of light balancing selective diffuser ceiling. Each lamp consumes 6½ amperes of direct current at 110 volts. The room is flooded with a soft even light, so that there is no difficulty in reading in any part of it. As the light sources are large and of a low intrinsic brilliancy, no uncomfortable blinding effect is experienced, even when looking directly at the lamps.

FIG. 1.—COMPOSING-ROOM ILLUMINATED BY GENERAL ELECTRIC ENCLOSED ARC LAMPS WITH INVERTED DIFFUSERS.

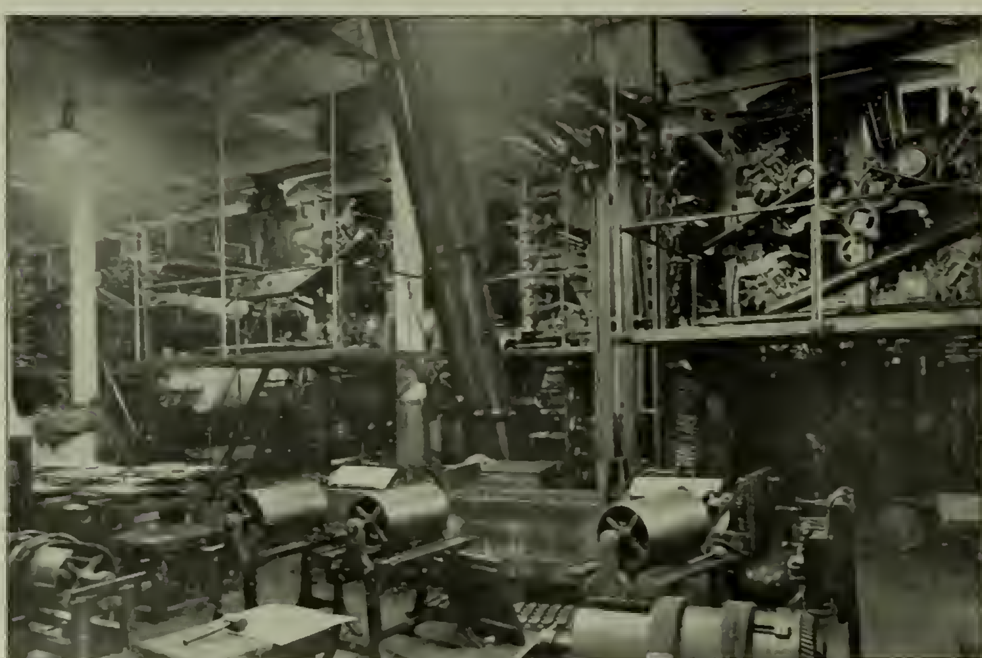


FIG. 2.—PRESS-ROOM IN WHICH THE USE OF SMALL INCANDESCENTS IS PRACTICALLY ABANDONED.

In the reportorial rooms, news is received, classified and put in readable form. It is a large open office, well filled with desks. All the desks must be illuminated, so as to facilitate rapid work without eye-strain. In the mailing room, newspapers are received from the press-rooms, counted and marked for distribution. These rooms have about 11 ft. studding and are lighted by 5-ampere direct current multiple enclosed arc lamps with concentric light diffusers. The lamps are hung as high as possible.

Type-setting and linotype work requires especially good light in order to permit the operators to read type rapidly. The metal faces of the type have dark dead surfaces without any color contrast, and the type is reversed, making it quite difficult to read, even under the best conditions. The illumination has been accomplished by the use of a large number of 5-ampere enclosed arc lamps. Owing to the height of studding, inverted diffusers are used. With this combination it is possible to hang the lamps quite high, concentrating the light downward, and producing a strong even illumination free from glare. The accompanying night photograph, Fig. 1, shows the arrangement of the room and the effective illumination produced.

Perhaps the most difficult department of a newspaper plant in which to obtain a satisfactory general illumination is the press-room. While the general illumination is not required to be as strong as in the type-setting department, the presses extend up within about three feet of the ceiling and the room is so filled up with overhanging platforms, rolls and other machinery, that it is very difficult to avoid dense shadows. By the use of the enclosed arc and the inverted diffuser, very good results have been obtained. The light has been projected into the machinery, so that the use of small incandescent lamps has practically been dispensed with. The illumination of this room is illustrated by the accompanying night photograph, Fig. 2.

About 75 enclosed arc lamps are required to illuminate the various departments of the present installation. These, with incandescent lamps in the smaller offices, halls, etc., make the *Boston Herald* plant one of the best lighted in the United States.

Westinghouse Desk Fan Motors

THE accompanying illustration shows the Westinghouse desk fan motor for the season of 1907. These motors embody the good features of previous years and have been improved to increase their efficiency and effectiveness. The Westinghouse fan motors are manufactured for use on both alternating-current and direct-current circuits and

ALTERNATING CURRENT DESK FAN MOTOR.

in two sizes, with 12 or 16-inch fans. The direct-current types are wound for 100 to 115 volts and 200 to 230 volts, and may be run at three speeds, the lower being 1000, the second speed being 1200 and the higher speed 1600 to 1650 revolutions per minute.

The alternating-current motors are made for frequencies from 25 to 133 and for voltages of 100-115 and 200-230. For all frequencies from 25 to 133 there are two speeds except for 40 to 50-cycle circuits, in which case there is a single speed. The higher speed ranges from about 1300 r.p.m. for low frequencies to 1600 r.p.m. for high frequencies, the corresponding lower speeds being 1150 and 1200.

Induction Motors in a Paint Mill

THE ordinary user of electrical power is familiar with the many advantages which are inherent in the induction motor when applied to practically any system of motor drive. But it is only when an application is made of this efficient machine to uses in which it alone is capable of adequately meeting requirements, that the full value of the induction motor is apparent.

Not long since the plant of the Wadsworth Howland Company, paint manufacturers of Chicago, was burned. Instead of rebuilding, the company purchased the paint works of the Geo. W. Pitkin Company, which was being equipped with Allis-Chalmers induction motors of the latest type.

The entire induction motor equipment, aggregating 300 horse-power, was placed with the Allis-Chalmers Company. The power installation is entirely electrical, including electric lighting, the underwriters allowing no gas or burning of oil in the building.

Six lead mixers will be driven by 30-H. P. motors. 10-H. P. motors will drive the white lead and putty chasers, three motors being used on tandem mills. 5-H. P. motors will be used on sampling mills, and others will be used for driving 20-inch water-cooled mills.

TESTING SET.

A New Decade Testing Set.

THE cut above illustrates a new type of testing set put on the market by Queen & Company, Inc., of Philadelphia. It possesses some interesting features, and is compact, the outside dimensions being 9¼ ins. by 7 ins. by 7½ ins. deep, weighing about 11 lbs. This is due primarily to a departure from the previous design of Decade Testing Sets, which, as shown by the illustration, consists in arranging the rheostat sections in arcs, while the bridge sections occupy positions within them. Practically the entire rubber top is utilized in this design.

The contact plugs and switches are of a new type, the latter being straight leaves and making contact with the under surface of each contact block, thus avoiding trouble from dust and dirt. This style of contact was adopted after a series of trials in actual service where its low initial resistance and constancy during long use were demonstrated.

Each rheostat has coils of the usual denominations and the ratio arms four coils each, and additional blocks are provided, so that one arc can be open circuited, and the opposite arm short circuited, this being frequently desirable, as in the Murray Loop Test.

The resistance coils are wound with manganin wire, shellaced and baked, and do not vary over a wide temperature range.

The galvanometer is of the D'Arsonval type, with a long narrow coil, securing sensitive and dead-beat action, and is similar to that used in their other high grade portable testing sets.

An Ayrton shunt gives the Galvanometer a wider range than heretofore, shunting values of 0.1 and .01 being provided. Keys are in series with both battery and galvanometer circuits and can be locked down by means of a thumb nut, or both keys may be depressed by the same finger. Binding posts and switches are provided, so the set can be used with an outside galvanometer or batteries, if desired.

Queen & Company will be pleased to supply full information and catalogues describing this set to those interested.

The Fielding Plug and Receptacle

The "Fielding" sectional mica plug and its receptacle are designed to meet the requirements of the National Electrical Code of the Underwriters, calling for a fireproof and waterproof device to carry up to 50 or 100 amperes, for distributing power to portable motors, marine and theatre work, for charging storage batteries, automobiles and other like purposes. The fact that with the "Fielding" plug there is no chance to reverse the polarity of the contacts makes it particularly desirable for those uses in which the direction of flow of the current is important, as with arc lamps and storage batteries; and as the plug is circular it does not cause the vexatious delays which are liable to occur with plugs of other shapes, when the attempt is made to use them in dark places.

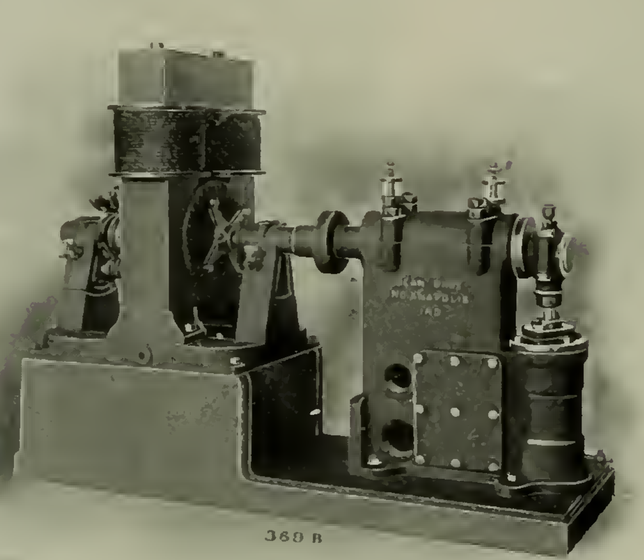
The receptacle is provided with a waterproof cap for closing the opening, and the split spring contact rings are located in a heavy block of glazed porcelain which is enclosed in a cast-iron box. The "Fielding" sectional mica plug is built up on a steel rod which is securely riveted into a copper cap. Mica disks are then threaded upon the rod, then a copper disk which is insulated from the rod, more mica disks and a second copper disk, then mica disks. The plug is finished with a neat aluminum handle which protects the contacts to which the flexible cable are connected.

SECTIONAL MICA PLUG AND RECEPTACLE.

The "Fielding" plug and receptacle are manufactured by Stanley & Patterson, of New York, in a number of sizes, and they will be pleased to furnish complete information to those interested.

An Electrically Driven Pump

The illustration shows a direct-connected electric pump now being built by Dean Bros. Steam Pump Works, Indianapolis, Ind., which runs noiselessly at high speed.



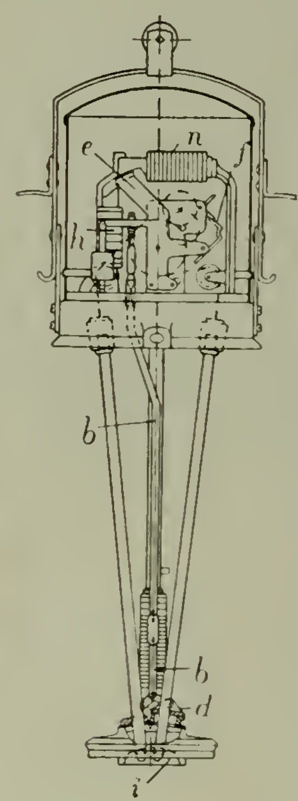
AN ELECTRICALLY DRIVEN PUMP.

The pump is double acting, and has low-lift valves of large area. The valves are accessible by removing a plate shown in front. The air chamber and vacuum chamber for pump are inside the casing. Suction and discharge connections may be taken from either side of pump. The upper opening seen inside of pump is for the discharge pipe connection; the lower opening is for the suction pipe connection.

A Flaming Arc Lamp for Interior Lighting

WHEN the flaming arc lamp was first introduced it was doubted if this type of lamp was suitable for other than general advertising purposes. This doubt was strengthened by the fact that it was especially theaters and shows of different kinds that availed themselves of the use of the lamp when it first came out, while the private consumer, the factory manager and the storekeeper appeared to be somewhat undecided regarding it.

The activity excited in pioneering the use of flaming arc lamps for distinctly commercial lighting has resulted not only in its extensive use for outdoor illumination, such as for streets, parks, docks, railway yards, etc., but also for indoor lighting. As illustrative examples in New York City, may be mentioned the terminals of the Erie Railroad, 23d and Chamber streets; the New York Post-Office mailing platform; Ansonia apartment house, Broadway and 72d street, where some of the lamps are erected 200 feet above street level; the Telharmonium Co., Broadway and 39th street, where the lamps are used effectively.



MECHANICAL CONSTRUCTION OF THE "EXCELLO" FLAMING ARC LAMP.

The flaming arc lamps used in each of these cases were supplied by the Excello Arc Lamp Co., of New York. The lamp brought out by this company for interior lighting operates on 6 amperes direct-current and can be connected in circuit by ordinary No. 14 wire. Its mechanical construction is shown in the annexed illustration. The carbons are placed side by side and slightly inclined toward each other. The arc, therefore, which is the source of light, has nothing below it to cast a shadow. Above the arc there is a protecting cup of white porcelain, which serves as a diffusing reflector to throw down the upward rays. Two small electro-magnets placed immediately above serve to keep the arc in its proper position, and prevent flickering. The luminous arc of the Excello lamp is about 1½ inches in length.

The Security Snap Socket

THE "Security Snap" socket which does away with the inconvenience of the screw-fastened type, has recently been perfected by the General Electric Company, and is shown in the annexed illustrations. Such a device has been particularly needed in fixture work where it is

METHOD OF DISUNITING SOCKET.

very inconvenient to adjust an ordinary screw-jointed socket in the husks. Moreover, the "Security Snap" socket is so constructed that it is not necessary to tip the shell to make the fastening. It may, therefore, be used in small husks as conveniently as in large ones.

Reference to the accompanying illustration will make the construction of the new socket clear. The security of the bayonet joint is combined with the convenience of a spring snap connection. In order to facilitate the assembly of the socket the cap and shell are marked with arrows and a star. To disunite the socket, the thumb is pressed on the star, the arrows brought into line, and a straight pull brings the socket apart. In assembling, the cap and socket are arranged with arrows in line, the shell is inserted in the cap, and turned until the socket locks.

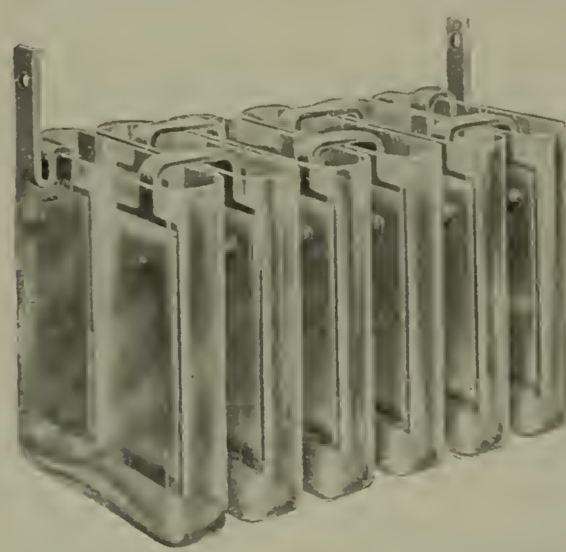
As the shell is fastened by three bayonet-joint catches, the connection is rigid, and the joint is held securely by the automatic lock.

A New Couple Type Storage Battery

IN operating fire-alarm and police-signal telegraphs, private branch telephone exchanges and railroad-signal systems only small amounts of current are required, but a closed circuit is used, and absolute reliability of operation overrides all other considerations. Closed-circuit work prescribes a low rate of discharge and freedom from polarization, and there is no primary cell of reasonable cost which is not polarized after standing on closed circuit for a few hours. This fact alone causes storage batteries to be greatly preferred for such work. Furthermore, the storage or secondary battery requires hardly more than one-third of the space occupied by primary cells. They require less cleaning and attendance, and the cost of maintenance and renewal of parts is less. The internal resistance is lower and a uniform voltage can be maintained.

For the work of fire-alarm telegraphs and similar installations, the most satisfactory form of storage cell has been found in the "couple" type. which has only one pair of plates in each cell, as small current capacity is needed at a low rate of discharge, and accessibility of parts and absolute certainty of action are essential.

Hitherto, separators of insulating material have been placed between adjacent plates in all couple types of storage batteries, excepting those in which the plates are covered with hard rubber or celluloid envelopes, which practically act as separators. Though they are kept as thin as may be con-



GOULD TANDEM COUPLE TYPE OF STORAGE BATTERY.

sistent with their office of preventing short circuits between plates, and are plentifully perforated, these separators necessarily obstruct the free circulation of the electrolyte, which is of the utmost importance to the maintenance of voltage. This objection is inseparable from the types of cells in which plates are placed face to face in order to concentrate great capacity in a small space. In many types of these cells electrolytic action takes place at varying rates, in different parts of the same grid, producing local distortion, which causes the active material to drop out as sediment and necessarily shortens the life of the plate.

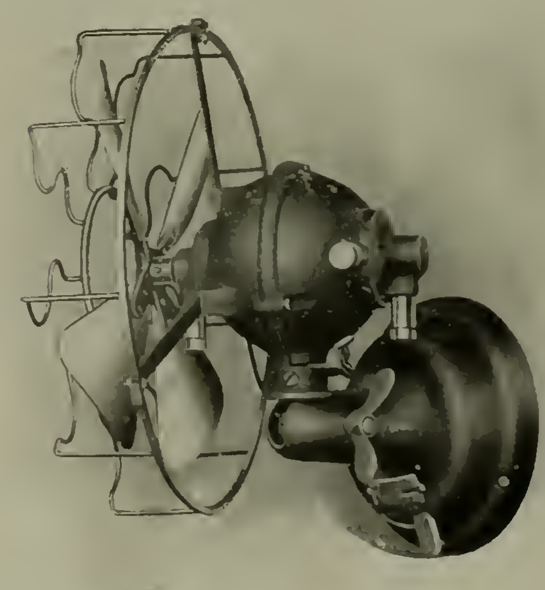
Necessarily, the action between the positive and negative sides which face each other is far more intense than between the sides turned away from each other, so that charge and discharge take place mainly on the facing sides, producing a tendency to buckle and wear unevenly. All these defects are completely eliminated by placing the plates edge to edge instead of face to face, as shown in the new Gould "tandem" couple type here illustrated.

It may be of interest that the fire department of one of the largest cities in this country has recently installed several batteries of these tandem couples and report unusually satisfactory results. The Gould Storage Battery Co. has on the press a very instructive booklet on Couple Types of Storage Batteries, copies of which will be furnished to anyone interested.

To supply current for fire-alarm and police-signal telegraphs, railroad signal and similar systems, modern practise usually provides duplicate-storage batteries for each separate circuit, so that one battery may be charged while the other supplies current for the circuit. This arrangement possesses the further advantage of keeping one battery in readiness at all times in case of accident to the companion battery, with sufficient capacity to allow a delay of sixty hours for repairs, without serious inconvenience.

New Universal-Joint Fans

THE Lundell direct-current fan motors, manufactured by the Sprague Electric Co., of New York, have been vastly improved for the season of 1907, with a view of embodying in one fan all the features of the solid-base desk, the swivel-and-trunnion desk, and the swivel-and-trunnion bracket types. This has been accomplished, as shown in the an-



WALL BRACKET FAN MOTOR.

nexed illustrations, by dispensing with the usual swivel and trunnion arrangement and substituting for it a universal joint as a connection between the motor and the base, enabling the fan to be used interchangeably as a desk or bracket type.

This construction presents obvious advantages to both dealer and user.

For the dealer, it greatly simplifies the problem of carrying stock, as he will need to carry only one type instead of three. To the user it offers a fan which may be placed with equal facility upon wall or desk, and can be readily adjusted to move the air in any direction desired.

Book Reviews

Wireless Telegraphy — An Elementary Treatise

By A. E. Kennelly, A. M., Sc.D. Published by Moffatt, Yard & Co., New York. Size, 5¼x7½ inches; 211 pages; 66 illustrations. Price, $1.

BY A. E. KENNELLY, A.M., SC.D.

So many books have already been written on the new art of wireless telegraphy, or radiotelegraphy, as we should, perhaps, now term it, that a new comer in the field is apt to be looked at askance, and to have its right of existence questioned. As the title of the present volume plainly intimates, this unpretentious work is of an elementary nature. The opening chapter is given up to a lucid discussion of waves and wave motion, which is accompanied by several illustrations. This is followed by chapters on electricity and magnetism (especially as these phenomena relate to the other), electromagnetic waves, radiated electro-magnetic waves, unguided electro-magnetic waves and plane electromagnetic waves; all of which takes up 96 pages of the book. It is, however, space well employed.

With chapter IX begins an interesting and instructive dissection on a simple antenna, sources of energy for feeding an antenna, and numerous other practical features of the art, such as tuning, etc. The book closes with a chapter on wireless telegraph working.

The author appears to have studiously avoided all reference to questions of privacy of invention in wireless telegraphy, and no particular wireless system is mentioned throughout the work. The book, therefore, is in no sense a work of reference, but because of the general information concerning the development and the underlying principles of wireless telegraphy which it contains, the student of the subject and the general reader will no doubt be pleased to give it a convenient place in their libraries. Considering the literary ability and the high professional standing of the author, they would be abundantly justified in doing so.

Concrete Factories.

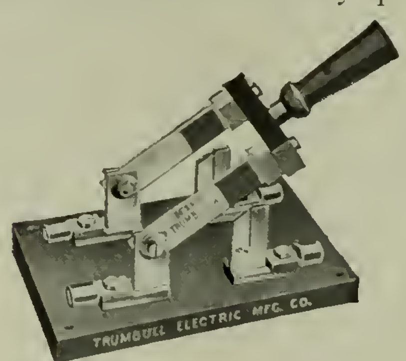
By Robert W. Lesley, Assoc. Am. Soc. C. E., published for the Cement Age Co., by Bruce & Banning, New York. Boards; 6½ x 10 ins.; 152 pages; numerous illustrations. $1.00.

This book offers in a condensed form a review of reinforced concrete factory construction, largely compiled from the many excellent articles on this subject which have appeared in the columns of the *Cement Age*, and has the advantage of treating the subject in a manner which can be understood by the layman. In addition, the book contains the report of the sub-committee on tests of the United States Advisory Board on Fuels and Structural Materials and a translation of the French rules on reinforced concrete, as issued by the Ministry of Public Works. There are a number of illustrations showing factories, completed and in process of construction, with the different methods of reinforcement. There is also an interesting article on finishing the surface of concrete in a manner to avoid the usual monotonous surface common to concrete structures.

Trade Notes

It has been stated that "changes and rulings on the fusing of knife switches have been so frequent and numerous in the last few years that a switch manufacturer in order to supply the entire line must go into the business in detail or find himself on the shelf. The increasing demand for alternating current requires an entirely different line of switches and has further complicated matters, the result being, that while a few years ago an assortment of a thousand switches was considered a good line, it requires to-day about thirty thousand different switches to make a full line." This is a large and prohibitive number to the small maker of switches, and is no doubt responsible for the closing up of some small switch factories.

The Trumbull Electric Mfg. Co. announce that in their new catalogue it will require forty pages to list 45,000 separate switches for every possible



combination; front and back connected, quick break, double break, quick break and double break, fused and unfused, plain and polished, direct current and alternating current, for 110, 250, 440 and 600 volts and ranging from fifteen to twenty-five hundred amperes; covering their respective classes, both type A and type C switches.

In design and workmanship the Trumbull switch has been long recognized as first-class in all respects, conforming carefully to the requirements of the Board of Underwriters, and in the type A switch showing rises in temperature from 25 to 50 per cent. below the underwriters' requirements as shown by recent tests of the Electrical Testing Laboratories. The type A switch, it is claimed, can carry 100 per cent. overload without injury.

The Trumbull Company claims to make more individual switches than any other manufacturer in the country, and to carry more knife-switch material in stock than any other firm in this line.

The Anderson time switch furnishes a means of controlling lights by day or night without the intervention of a watchman; and is a useful device to the merchant who wishes to regulate his window display lighting to those hours when it will be effective; and to the central station manager who has lights installed on contracts calling for their being extinguished or lighted at a set time. The device is well constructed, reliable and does not go to sleep. It is manufactured by Albert & J. M. Anderson Manufacturing Company, of Boston, Mass., who will be pleased to hear from those interested.

The approach of summer calls to mind the electric fan, and a gentle hint in this line has been received in the shape of a catalogue of "The Standard" direct-current fans, issued by the Robbins & Myers Company, of Springfield, Ohio. This line of fans is very complete, covering all requirements, and the catalogue should be in the hands of all central station men.

The Jeffrey Manufacturing Company, of Columbus, Ohio, has recently issued two pamphlets in regard to their methods of handling coal and ashes at power plants. One of the pamphlets treats of their overlapping lip swivelling bucket for conveying and elevating purposes; the other illustrates the uses of the Jeffrey grab bucket. In the latter is shown a special application of the grab bucket method to the peculiar conditions existing at one of the Armour Packing Company's plants. A gantry crane being mounted upon the top of the boiler house, by which the coal is raised and deposited in a hopper from which it passes to the bunker.

The managers of hydro-electric works will be interested in the "Improved Governor" for water wheels which is manufactured by the Holyoke Machine Co., of Worcester, Mass. This governor was invented by Nathaniel Lombard, who is well known by his previous work along this line.

Soldered connections on cables are not only difficult to make but are costly; the work is tedious, and for that reason there is a continual temptation upon the part of the workman to slight it. Such joints are more or less vexatious, no matter how good they look on the outside, and are liable to be all wrong on the inside, owing to the difficulty of getting the solder worked thoroughly through the joint. Another source of trouble arises through the use of acid fluxes which have a corrosive action on the cable and which cannot be removed effectually. The solder joint may also melt out owing to excess current passing to a short circuit some distance away.

The Dossert solderless connectors and joints are designed to obviate all troubles of this nature and to displace the soldered joint. Permission for their use is granted by the Boards of Fire Underwriters, and a large number of prominent central stations, electric railways and railroads are using these joints. The connectors are made to suit all sizes and combinations of sizes of solid and stranded conductors and can be secured from a number of the prominent supply houses. A skilled mechanic is not required to apply the Dossert connector, and the rapidity with which they can be applied is particularly valuable in emergency work. The connectors are made by Dossert & Company, of New York, who will be pleased to send complete information in regard to them to all interested parties.

The Fort Wayne Electric Works, Fort Wayne, Ind., have issued a new index to their bulletins, dated January 1, 1907, which supersedes the previous index. They have also issued a new bulletin, No. 1090, concerning the "Wood" series alternating current arc lighting system, which takes the place of bulletin No. 1070.

News Notes

The Ball Engine Company, Erie, Pa., builders of automatic and Corliss engines, has opened a branch office at No. 1,213 Chemical Building, St. Louis, under the management of Mr. O. L. Collins.

The Rail Joint Company of Canada, Limited, has been organized, and taken over the patents and business of the Continuous Rail Joint Company of Canada, Limited. Headquarters are at 216 Board of Trade Bldg., Montreal, Canada. They have commenced the manufacture of their products in Canada and are prepared to make prompt deliveries.

The thirtieth annual convention of The National Electric Light Association will be held in Washington, D. C., on the days of Tuesday, Wednesday, Thursday and Friday, the 4th, 5th, 6th and 7th of June, 1907. The headquarters will be in the New Willard Hotel—the entire tenth floor of which will be devoted to the exhibits of the associate members and the general meetings of the convention.

W. E. Rundle, inventor of the Rundle graphic cable chart, has worked out a standard cable and manhole sheet, which he is now prepared to furnish licensees. These sheets, 22-inch by 29-inch in size, each record ten miles of cable and are bound in loose-leaf black flexible leather binder. The system is used by the Interborough Rapid Transit Co., the Manhattan Elevated Railway Co., the New York & Queens County Railway Co., the Niagara Falls Power Co., the United Railways & Electric Co., of Baltimore, the Consolidated Gas, Electric Light & Power Co., of Baltimore, and the London Underground Electric Railways Co.

The Ball Engine Company, Erie, Pa., has opened a branch office at No. 39 Cortlandt Street, New York, for the sale of its automatic and Corliss engines under the management of Mr. Lancelot Copleston, who is well known to the New York trade.

Harvard University is conducting an extensive series of laboratory tests on insulating materials and compounds. It has recently ordered from the Electric Cable Company, of New York, a supply of Voltax, the high-potential insulating compound, which during the last year has come into extensive use by the street railway companies in this country and abroad. The results of these tests will be watched with much interest by electrical engineers. Another order is from the Brooklyn Navy Yard, which has just purchased a quantity of Voltax for use in electrical installation work at that place. The company has also recently received large duplicate orders for Voltax from the New York Central & Hudson River Railroad Company for use at High Bridge, where extensive electrical work is being done, from the Philadelphia Electric Company, and from the Public Service Corporation of New Jersey.

The Royal Motor Car Company, of Cleveland, Ohio, are providing for a power plant, in addition to the other buildings, to serve their new factory. As soon as their advisory engineers, Dodge & Day, of Philadelphia, have decided on the nature and amount of power required, the details of the building and equipment will be determined upon.

New Catalogues

Charles J. Jager Company, of Providence, R. I., is sending out an interesting bulletin in regard to gasolene engine driven generators for supplying current to isolated country residences and upon vessels. These sets are made in a number of sizes ranging from 3 to 60-horse-power.

A. M. Clark, of 90 John Street, New York, is sending out a catalogue of a number of electrical toys designed for the children. The current for the various magnetic engines can be supplied from dry batteries, and this type of mechanical toy is much safer and more interesting than those driven by steam.

The Automatic Refrigerating Co., of Hartford, Conn., is mailing a pamphlet covering their small sizes of refrigerating apparatus. This apparatus is designed to meet the needs of retailers and hotels which do not have a sufficient amount of cooling work to call for a steam plant. The compressor is driven by an electric motor or gas engine. It might pay central station men to look into this method of developing a demand for current, as refrigerating work is of necessity distributed over the entire twenty-four hours of the day.

The National Carbon Company, of Cleveland, Ohio, desires to have all users of arc lamps note the cleanliness of the globe and the brilliant light to be secured by the use of their "Columbia" carbons. In order to insure facilities for doing so they offer to supply a sufficient quantity of these carbons to enable a working test to be made.

The Oneida Community, Ltd., Oneida, N. Y., are sending out a folder describing their well known make of galvanized chain. The Oneida chain has replaced ropes and wire cables in many places and its merits have secured it a large number of users. The Community is well known for the high grade of work they turn out in all lines and their galvanized chain and the special attachments for securing it to both the lamp and the pole are made according to their standards of workmanship. This chain is rust-proof, and snow and sleet have but little effect upon its flexibility and ease of operation. About 2,000 central stations have adopted this method of suspension and the number of users is rapidly increasing.

A very attractive catalogue on cement-making machinery was recently sent out by the Power & Mining Machinery Company, of Milwaukee, Wis. The machinery illustrated and described includes gyratory rock and ore breakers, crushers, quarry cars, crushing rolls, conveyors, elevators, screens, mixing mills, feeders, rotary dryers, ball-tube mills, inclined-vibrating screens, air separators, rotary kilns, coolers, clinker conveyors, coal crushers and automatic scales. The Loomis-Pettibone Gas Producer, built by the company, is also briefly dealt with. Several pages are devoted to a description of the method of manufacture and the preparation of the raw material by the dry process.

The equipment for the series alternating-current arc-lighting system of the Fort Wayne Electric Works, of Fort Wayne, Indiana, is illustrated and described in a recent bulletin. The apparatus dealt with includes the regulator, the transformer, the switchboard, the arc-lamps and the multiplex-lighting arresters. An instruction book accompanies the bulletin. Other literature sent out is devoted to single-phase switchboard panels, direct-current switchboard panels, and an index to bulletins Nos. 1001 to 1089.

A revised edition of a bulletin dealing with the Moore vacuum-tube light was recently issued by the Moore Electrical Company, of Newark, N. J. Illustrations are given of various installations of Moore tubes and the advantages of this form of illumination are fully set forth.

A guide to the design of medium and small capacity central station switchboards was recently issued as a bulletin by the General Electric Company, of Schenectady. The bulletin was inspired by the hope that it might be of assistance in designing switchboards for moderate-sized stations, and represents the latest alternating-current practice. Other literature sent out deals with "Type C Q" motors, ranging from 1-6 to 20 H. P. fan motors, signal relays for use in connection with railway signal apparatus, railway signals, automatic-starting compensators for alternating-current motors, and price lists of carbon filament lamps and miniature incandescent lamps.

Personals

The Trustees of the Rensselaer Polytechnic Institute have decided to establish courses in mechanical and electrical engineering. The recent gift of one million dollars from Mrs. Russell Sage, and other recent gifts, through which they have been able to increase the value of their plant for the purposes of instruction, enables them to do this.

These courses will be very general engineering courses, similar to the civil engineering course now given at the Institute.

J. R. Lovejoy has been appointed general manager of the sales department of the General Electrical Company. Mr. Lovejoy has long been known to the electrical fraternity and this title is a formal recognition of the responsibilities with which he has practically been charged for the last two or three years. Mr. Lovejoy was born at Columbus, Ohio, in 1863. After a post-graduate course at the Ohio State University, from which he received the degree B. Sc., he entered the employ of the Thomson-Houston Electric Co., at Lynn, Mass., August, 1886. Here he gained his practical experience and graduated from what was then known as the expert course to take up engineering work in the Boston office of the company. Later his time was devoted to executive duties at headquarters, and when the Thomson-Houston Company was merged into the General Electric Co. in 1892, he became general manager of the supply department. In 1900 he was made also manager of the railway and lighting departments of the General Electric Co. He is an officer and a director in several subsidiary companies. Mr. Lovejoy is a director and member of the executive committee of the Schenectady Trust Company and was one of the organizers of that concern. He is a member of the American Institute of Electrical Engineers, the Franklin Institute and the American Society for the Advancement of Science, as well as several organizations pertaining to electrical science.

In addition to his diversified business duties, Mr. Lovejoy finds time to take an active part in promoting the welfare of the Mohawk Golf Club of Schenectady, of which he is president. He is also a member of the Mohawk Club of Schenectady and the University Club of New York.

Findlay S. Douglas, who has been connected for a number of years with the sales department of the Sprague Electric Company, of New York, has been appointed manager of the motor and generator sales department of the New York office. Aside from his extensive acquaintance in the electrical field, he has also an international reputation as an amateur golfer, having held the title of amateur champion of the United States.

H. J. Clark, of Fort Dodge, Iowa, has been appointed general superintendent of the Citizens' Railway and Light Company, Muscatine, Iowa, succeeding Frederick Potvin, who goes to the main office of the company at Grand Rapids, Mich.

Ralph D. Mershon sailed Saturday, February 16, for London, England, to take up there matters relative to the Victoria Falls power scheme, in connection with which he has been retained for some time past. Mr. Mershon does not contemplate visiting South Africa at this time in connection with this work. His present trip will not extend beyond London, Paris and Berlin, and his absence from this country will be limited to about thirty days.

S. W. Childs has been placed in charge of construction on the Tri-City work which is being undertaken by J. G. White & Company at Rock Island, Ill. Mr. Childs has completed the work of electrifying the Fort Dodge, Des Moines & Southern Railroad, and has been located at Boone, Iowa, for the past nine months. Under his direction a power-house and substations have been constructed at Frazer, Iowa, and forty miles of overhead line and track have been built. The gas and electric lighting plants and street railways at Moline, Rock Island and Davenport, are being reconstructed at a cost of $2,225,000, and the entire work has been placed in charge of Mr. Childs.

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Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauhurg Montmartre, Paris

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J. H. SMITH, Editor

Editorials

Leading Articles

Central Station Growth

In commenting on the factors in central station growth, the *Electrical World* of April 6th has this to say: "Analyzing the causes which make it possible for central stations to grow, we find one to be the increase in population," and further along in the same easy narrative this equally obvious truth: "This leads us up to the second and very important factor in central-station growth, namely, the increase in wealth per capita."

The effect of these two natural conditions is pointed out with great perspicuity to the reader, but we venture the humble opinion that neither is a very strong factor in the growth of central stations or in the increase of electric service at the present time, and we hold that rapid increase of population and high per capita wealth are merely passive, favoring conditions; and also, that they will be controlling factors only when the public uses electric current as it uses bread, soap or any other article of absolute necessity.

What nonsense is it to hold either of these conditions of importance when central stations in small rural cities of 10 to 20,000 population can show an annual growth of 10 to 20 per cent., this being four or five fold the rate at which the population increases; and this, too, in towns of which the wealth per capita is low.

The dominant factors in the situation are dismissed in a single sentence: "Among the artificial stimulants can be enumerated lower rates, solicitation, advertising, and the introduction of new appliances, although the latter might, perhaps, better be classified as a natural cause."

The veriest central station tyro knows that these are the real and controlling influences in central-station activity, and that there is as much money to be made in a manufacturing city as in a city of homes.

The truth about the matter is, that the use of electric service is still so limited that the personal influence of the individual at the head of the company is the most important factor in the situation. To illustrate the proposition: The president of the electric corporation in one of our largest cities said to his solicitor general, "I want you to hire men to sell current who are primarily salesmen, and not technical men." That was the most important action which that company took that year, and from that time it grew rapidly. The same policy on the part of another corporation, in a city of a half a million, led to a 25 per cent. annual growth in income, in a city where the annual increase in population is three per cent., and the increase in per capita wealth about ten cents per year. Personal push on the part of the chief executive officer of the company is the most important influence now at work and is likely to remain so for the next decade, when it is hoped that the population and wealth per capita statistics will be seen to have a slight appreciable effect, but like the measurement of some stellar parallax it will probably require some centuries to determine the exact drift of their influence.

Next after personal effort is the question of rates, or, more properly, the reasonableness of the commercial proposition which is handed to the public.

After this the adoption of a wise policy in going after the business. As far as possible the efforts of solicitors should be concentrated on streets where there are existing feeders, so that extra capital is not required for extension. The successful New York Edison Company has, as nearly as it could, followed this plan with wisdom. On the west side of New York very few cross streets carry their mains. Selling effort is almost entirely confined to the downtown section. Getting a scattered business will check the growth of a company quicker than a bad-tempered public.

The next most important factor in central-station growth is perhaps the improvement or betterment of the service which has occurred in the past few years. The engineering features which have improved the service are now fairly well known, and they are rapidly being introduced by the smaller companies. Create a successful central station in a large city and it will be copied in the smaller places as quickly as this method can be studied, and what can be done in one city may be done in another. But we shall have more to say about this in a later issue.

Lightning Phenomena

LIGHTNING phenomena and lightning protection were again discussed at the March 29th meeting of the American Institute of Electrical Engineers. Dr. C. P. Steinmetz presented a paper dealing with abnormal voltage oscillations in electrical systems in which he points out that it is most essential to make a "study of transformer connections and their operating conditions, of generator wave-shape and connections, of the possible origin of higher harmonics of the potential wave, the construction and location of underground cables, the protection of their joints, the desirability, size and location of reactive coils." Mr. Steinmetz presents in full the fundamental equations of the standing wave and makes a calculation for a short-circuit surge on a 50-mile, 30,000-volt, 25-cycle transmission line of No. 0000 wire. He discusses, also, in an elementary way, the origin of internal disturbances, most of which is familiar to students of this subject. The paper does not contribute anything new to what is already known on this subject, and its real merit lies in the logical and clear classification of lightning disturbances with the terse descriptions of their origin and behavior.

The analogy which Dr. Steinmetz draws between ocean surf and waves of static electricity is perhaps only intended for the layman, as the similarity is not scientifically correct. An advancing wave of practically infinite front, changing its shape in shallower water, but still pressing on until it finally breaks, is hardly analogous. The electric phenomenon is, however, strictly analogous to the behavior of water in a trough of smooth, frictionless and perpendicular sides. The length of the trough must be practically infinite with respect to its length, and whenever the capacity lessens, there the trough must taper in width. The emphasis which Dr. Steinmetz lays on capacity relations in the various circuits cannot be too strongly put.

The paper by Messrs. Rushmore and Dubois presented a large number of lightning photographs; a review of their opinion of the horn arrester, which was characterized by them as an emergency device of doubtful utility; a suggested plan for pole-line protection; and the experimental results of a 2300-volt multi-gap arrester, accompanied by a full theoretical explanation of its behavior.

The paper is well written, and is interesting, but we must take exception to some of its statements.

The pole-line construction recommended is undesirable, if for no other reason than its very weak mechanical construction and the great number of opportunities for unnecessary grounding of the line, due to the horns. On wooden poles the bringing of the ground connection in the neighborhood of the insulators, as shown, will oftentimes probably aggravate pole burning.

The curves of potential shown across a series of gaps will be distorted in actual practice, on account of the leakage of current from cylinder to cylinder. Furthermore, if the net result of this arrangement is inconvenient, a considerable air gap in series with the smaller gaps will hold back the line potential and not add materially to the breaking-down voltage.

The arrester layout, as described, is for 2300 volts, and requires a breaking down of 9 shunted gaps to ground for a free discharge instead of 6, as in Wurt's arrester for the same work.

It is doubtful, also, if much can be expected of a type of arrester tested out at so low a voltage. The real difficulties begin only to be encountered at 20,000 volts and upward, and it is only at these relatively high voltages that the market devices are put to serious strain.

The paper by Prof. Creighton is reprinted elsewhere in full, as it is replete with information of value and shows probably the most complete collection of oscillograms yet presented in a study of these conditions.

It seems very questionable whether the results reported in this paper will give any criterion of the non-arcing quality of these arresters on large power, high-voltage circuits. Tests on full size plants are absolutely necessary, and the tests reported would seem to be all on 2300 volts with a very limited capacity. Consequently, the condition in which no arc follows in gaps shunting a resistance is easily attained. This is an old condition, but would not have been found the same in all probability in connection with a discharge on a powerful circuit. Furthermore, two of the figures indicate that the static spark has been applied to the arrester in the early part of the cycle when the electromotive force is relatively low. While this is perhaps the proper method when the power to suppress an arc easily started is being tested, it is not the proper method of determining whether or not an arc will start in gaps shunting a resistance. The static spark should evidently be produced when the main voltage is at a maximum to get the most favorable conditions for following the shunting gaps.

Just what the author means by rectification of vapor is not clear, as vapor is an aggregation of molecules which simply vibrate at will in all directions. His idea is probably borrowed from some loose explanations of the action of the Cooper Hewitt mercury vapor rectifier, though even in this apparatus there is no such thing as the rectification of vapor.

The data given of the author's electrolytic arrester are valuable and from a scientific point of view of great interest. The type of cell will probably be very difficult to adapt to successful commercial operation.

The Vertical Turbo-Generator

ON Monday, April 15th, at 8.01 P. M., an alarm of fire was turned in from the No. 1, Waterside station of the New York Edison Company, owing to a short circuit in the stationary armature of No. 10 alternator, a 5000 k.w. General Electric turbo-generator of the vertical type. The burn-out occurred shortly after the machine was placed in operation, during the peak of the load and resulted in the forced shut down of some of the substation rotary converters, causing considerable inconvenience to current consumers.

No cause has been definitely assigned for the burn-out, which was localized in the high-tension winding of the generator, involving nearly all of the coils. Some of the wires were forced out of the slots and cut by the revolving field. No damage was done to the high-tension switches nor to the mains leading to the machine.

This is not the first apparently inexplicable burn-out of large-sized, vertical-type turbo-alternators. A similar accident occurred in the Fisk Street Station, Chicago, in which two machines were involved. In Chicago the insulation of one machine gave way, burning it out and throwing 100 per cent. overload on another machine, which burned out also.

In the recent case, in New York, the burned-out generator was one of fifteen units, having a total capacity of 57,000 k.w. The resulting overload was therefore too small to involve the other machines in the trouble.

These accidents both occurred to machines which were thrown in at peak loads, and the burn-out developed a short time after the machines were cut in on the bus.

In both cases, at the Waterside No. 1, and at Fisk Street, the primary cause of the trouble was due to the breaking down of the armature insulation. One of the causes which undoubtedly contributes to this breakdown is steam leaking from the turbine shaft gland condensing on the comparatively cool surfaces of the generator. Wet steam has a very bad effect on all sorts of insulation, and the construction of the vertical turbine is particularly well adapted to expose its windings to leakage while the machine is under steam.

One of the first lessons those working with electrical apparatus is the danger of dampness to insulation. The above maxim is so well understood that skylight drippage is always avoided, even though its occurrence be of a problematical and intermittent character. Steam pipes whose joints may leak are carefully arranged so that they do not come immediately over or under electrical machinery, and the importance of warming the machines up gradually is thoroughly emphasized by the manufacturers. There is just as much danger in condensed steam as in water.

The cases cited of the destruction of 5000 k.w. Curtis alternators of the vertical type without any damage occurring at the switchboard or in the generator feeders indicates that their destruction was due to internal causes, and in view of the well-known care which is taken in the insulation of such machinery, it is fair to presume that its loss was not due to carelessness in workmanship. A consideration of the structure of the vertical type of turbo-generator will reveal the likeliest source of trouble.

In the vertical turbo-generator we have a steeple; its base a condenser or an exhaust steam chest; upon this is superimposed the turbine; the generator next and, crowning all, a governor. Steam for use with turbines is hot, superheated in fact. Therefore, to avoid a difference of one hundred or so degrees between the bottom portion of the generator and its top, a separator is placed between the turbine and its generator. At the lower end of the turbine is a vacuum; on its upper side, a high steam pressure. The vertical shaft passes through the top cover of the turbine. The possibility of steam leakage in this arrangement is so obvious as to necessitate the use of a gland at this point.

The function of a steam gland is to reduce or prevent leakage. Where it is made tight enough to stop leakage the mechanical efficiency of a machine is reduced. Furthermore, a gland never remains tight, except when not working. For the foregoing reasons steam cylinders are tabooed forms of motive power for switch control. Steam, after it has wormed its devious way through a gland, is wet; very wet. Hence, it will condense to a greater or less degree on any surface whose temperature is under one hundred degrees centigrade, which is well above the usual working temperature of generators.

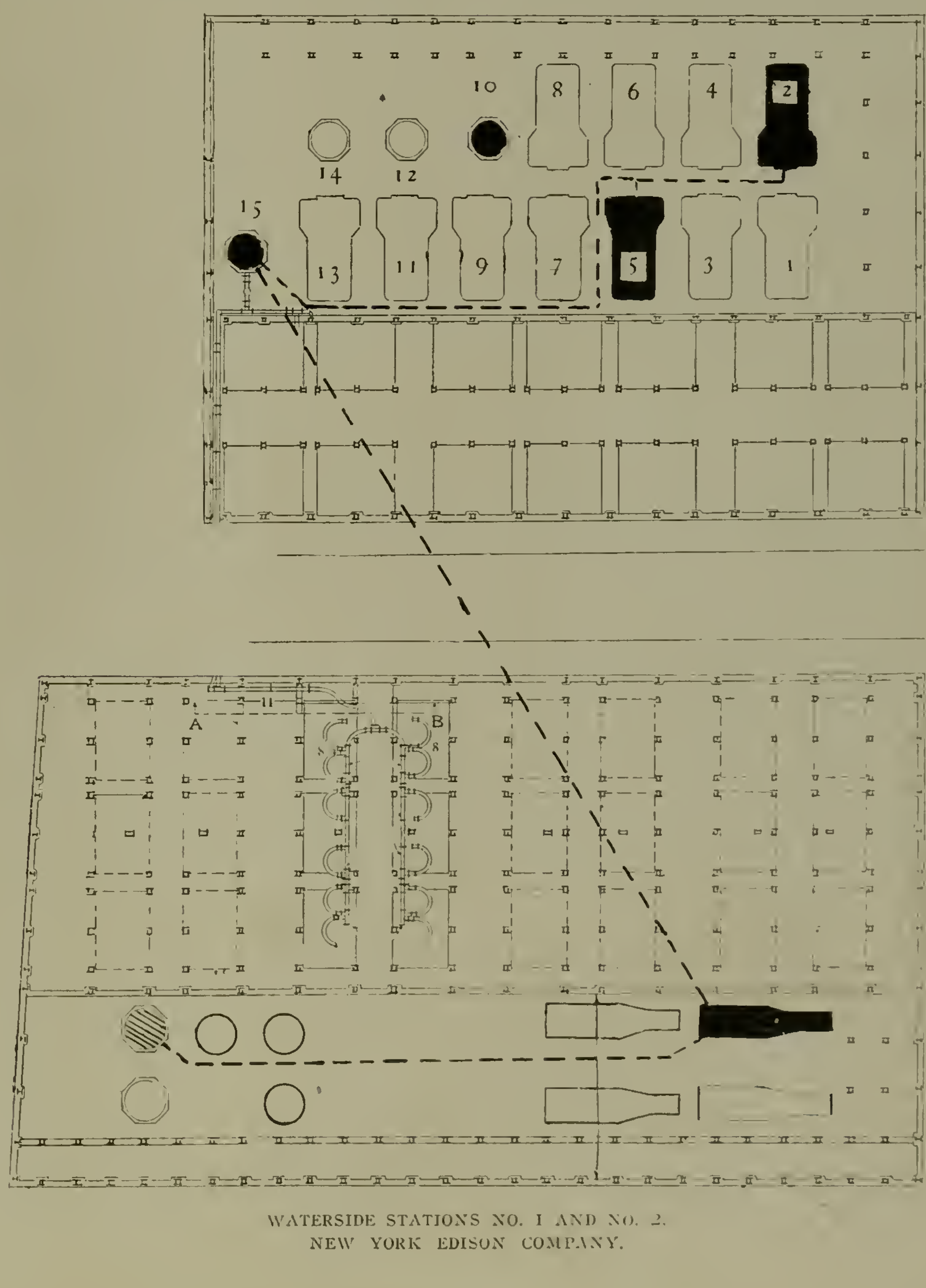
A leaking gland in the vertical type of turbo-generator is equivalent in its action to a small steam jet placed where it will blow through the electrical portion of the machine. It is futile to contend that such gland leakage is small, or that the gland is always tight, and that its possible leakage is too small to consider when just a few drops of water are probably sufficient to break down the insulation. The accumulation of the water does not occur at a single transfer but is a steady and gradual accumulation of dampness.

Central Station Operation

ON Saturday night, April 20th, about 9.15 P. M., three of the large generators in the Waterside Power Station, No. 1, of the New York Edison Company, were badly burned in a disastrous short circuit that resulted in the complete shut-down of Station No. 1. About three hours later, as a result of the trouble in Station No. 1, a large turbo-generator in Station No. 2 short-circuited after a remarkable performance.

Generator No. 2, generator No. 5, each 3500 k. w. direct-connected, General Electric, three-phase, 6600 volt alternators and turbo-generator set No. 15 of 5000 k. w. capacity were the only machines in operation in Station No. 1, and were tied in parallel on the main bus. At the same time, there were in operation in Station No. 2 one 7500 k. w., 25-cycle, three-phase, 6600 volt, Westinghouse turbo-generator set, and one 8000 k. w. General Electric turbo-generator of similar characteristic, both on the main bus of Station No. 2. The main bus of Station No. 1 is connected to the main bus of Station No. 2 by an automatic release circuit breaker, set to trip when the cross current between the stations reaches 13,000 k. w.

The destruction of a number of oil switches in the distribution system.



WATERSIDE STATIONS NO. 1 AND NO. 2.
NEW YORK EDISON COMPANY.

taken in conjunction with the blowing of a manhole, suggest that after the initial short circuit in the feeder system there was a short circuit at the oil switches in the substation resulting in a direct short circuit of the generating station.

An attendant standing near generator No. 2 noticed the quick speeding-up of this machine, and he fled from the spot so panic stricken that he left an elderly lady whom he was showing about the plant. Quickly realizing his lack of thought for at least, her safety, he dashed back and hurried her away. Within a few moments the low pressure crank broke, the top cylinder head was blown out, and the generator caught fire. Within thirty seconds generator No. 5 had short-circuited and was ablaze, and exactly three minutes from the beginning of the trouble turbo-generator No. 15 short-circuited. Almost immediately thereafter the automatic trip between the main bus in Station No. 1 and that in Station No. 2 broke, following the rush of current, and a load of approximately 18,000 k. w. fell upon Station No. 2, overloading the two turbo-generators in operation in that station.

Immediately following the shut-down of Station No. 1 and the isolation of the substation which it feeds, the down-town load was picked up by the substation-storage batteries, which can deliver the station capacity for one hour, and the lights were raised again. At the end of their discharge limit the batteries gave out, though in the meanwhile a number of reserve machines in Station No. 1 were gotten under steam and the voltage in the alternating-current bus was raised to about 5200 volts. The inability to maintain a higher voltage was probably due to the destruction of oil switches in the station, which prevented the operation of more units.

Simultaneously with the disaster in the station, a manhole at the corner of Forty-fifth Street and Broadway blew up, due to an explosion of sewer gas, which was probably ignited by a short in the feeder system, and a high-voltage surge of between 8000 and 9000 volts was indicated in the station. The voltage at the station rose about one-third above the normal and subsided to zero, after which it was gradually brought up to 5200 volts.

From the time of the disaster until about twelve o'clock, Station No. 2 carried approximately 18,000 k. ws., heavily overloading the two turbo-generator sets in operation, and pulling the frequency down to about 18 cycles per second with the power factor about 70 per cent. At that time the Curtis turbine in No. 2 lost its vacuum, owing to the failure of the circulating pump, which was motor driven from the feeder circuit, on which the voltage had gradually dropped until it reached a point at which the motor was unable to carry its load. The load of this machine dropped to 5000 k. w., throwing 13,000 k. w. on the 7500 k. w. Westinghouse machine. It continued to carry this load at a power factor somewhat less than seventy, which was approximately an overload of about 300 per cent. of the normal current. This was carried until 12.45, when the machine broke down under this enormous current.

It is somewhat idle to speculate on the actual conditions responsible for this disaster, but certain things appear.

One of the three machines in Station No. 1 must have motorized, and at least one of the other two must have generated the excess voltage. It would have been impossible for either one of the 3500 k. w. machines or both together, to have speeded up and delivered the extra current, so it is supposed that the 5000 k. w. Curtis turbine in some manner began to race, raising the voltage and frequency, and carrying the two small engine generators with it.

The Corliss steam engines are provided with an emergency block, which throws the valve reach rod out of action and stops the motion of steam and exhaust valves in case of a runaway. In this case the engine being driven at a high speed by its connected generator the stoppage of the steam and exhaust valves probably trapped a cylinder full of steam and this was compressed until the cylinder head gave way or the crank broke. Either or both of these breaks could result from the emergency trip block acting when the increase in speed was due to motorizing of the generator. In ordinary cases of runaway engines the stoppage of the valve motion results in stoppage of the engine and the residual fly-wheel inertia of the moving parts is rarely sufficient to cause damage.

Several things occurred that foresight might reasonably have avoided.

In the event that the first attendant who observed the pending disaster had kept his head, and shut down engine No. 2, or there had been any adequate means of quickly cutting off the steam header of the generator sets, this disaster might have been lessened, if not prevented.

Likewise, had the circulating pump for the Curtis turbine in Station No. 2 been steam driven, this machine could have held up its load, regardless of electrical troubles, and Station No. 2 would have been kept in operation until sufficient reserve power had been obtained to carry its load. The foolishness of driving auxiliary power equipment by electricity will probably now receive the recognition it deserves, as this practice has lately been condemned by a number of engineers of prominence.

Rubber Insulation

THE insulation of electric transmission cables is of the utmost importance to their users. One of the materials of insulation is rubber, a substance which readily lends itself to sophistication. The manufacture of this material from crude rubber is a secret process, and the merits or demerits of the compound depend upon the process, as well as upon the materials incorporated with the rubber. The merits of a rubber compound cannot be determined by any single test, and the requirements outlined by Mr. Del Mar are undoubtedly severe.

Mr. Del Mar points out the methods to be followed, enabling the user to construct a suitable specification, which, favoring no one manufacturer, will broaden the competition for their business.

Rubber Insulation

WILLIAM A. DEL MAR

ADVANTAGES OF RUBBER.

THE principal insulating materials used in the manufacture of electric cables are paper, varnished cloth and rubber compounds. Of these the only type that is waterproof and weatherproof to any practical extent is the rubber compound.

ADULTERATION OF RUBBER.

Paper and varnished cloth insulation, being composed of staple commercial fabrics, impregnated with compounds of well-known oils, etc., are not susceptible of adulteration or imitation, and consequently do not suffer much in quality from attempts by the manufacturers to lessen the cost of production.

Rubber compounds, on the contrary, being made of any material mixed with any amount or grade of rubber, are easily adulterated and even imitated, the extent to which this is carried on being so great as to make engineers adopt other types of insulation wherever possible.

RUBBER GUM.

Rubber is a gum extracted from a tree which grows in the tropical countries of Africa and South America. The quality of this gum varies in many ways, but the characteristic which most affects its commercial value is its dryness. This is because the native gum is usually found associated with volatile matter, known to the trade as "extract," which, when the rubber is made up, gradually evaporates and leaves the rubber in a dry and brittle condition. This phenomenon can be observed in the behavior of a common elastic band which has been in use for several months, the drying being accompanied by oxidation.

It is therefore of the utmost importance that the rubber used in the preparation of insulating compound should have a low percentage of volatile extract. The volatile matter is usually estimated by digesting the gum in acetone for several hours, and thereby dissolving out the extract. The proportion of acetone extract in different grades of gum varies from less than 1 per cent. to over 20 per cent., the grades having the smaller proportion of extract being generally from South America.

The best grade of South American rubber is known as fine Para, and is the most desirable kind to use in insulating compounds. While it is usual to specify that compounds shall contain only the finest dry Para rubber, there is no practical way to ascertain whether the rubber did actually come from Para. Furthermore, it is of no practical import whether the rubber is from Para or any other place, provided that the percentage of extract does not exceed 3 per cent.

VULCANIZATION.

Rubber gum, in its native state, is of little use for insulating purposes, owing to its property of absorbing water and oxidizing. When mixed with sulphur and heated to a temperature of from 248 to 302 deg. Fahrenheit, a combination takes place which renders the rubber more staple and at the same time increases its mechanical and electrical strength. This process is known as vulcanization. All rubber insulation is made of vulcanized rubber.

Under-vulcanized rubber partakes of the properties of the native gum; over-vulcanized rubber is brittle and inelastic. In fact, heated to between 350 and 400 deg. F., vulcanized rubber entirely loses its elasticity and becomes a hard and brittle substance known under the name of vulcanite.

It is therefore of the utmost importance that rubber insulation be vulcanized as much as possible without losing its elasticity.

The process of vulcanization is said to slightly increase the percentage of extractive matter, and the manufacturers generally introduce an additional amount in the mixing process. The total amount in the finished compound should not exceed 5 per cent.

THE ADULTERATION OF RUBBER.

Pure vulcanized rubber is not a practical insulating material for the following reasons:

First. It can be adulterated with a large proportion of comparatively cheap material without losing its good qualities. The pure product, therefore, cannot compete, commercially, with the compound.

Second. The insulation is not sufficiently firm to withstand mechanical strains, unless compounded with inelastic substances.

It has been found by experience that 60 to 70 per cent. of adulterant may be added to rubber gum without destroying its useful qualities after vulcanization. Above this percentage, the qualities of the rubber cease to predominate, and the compound partakes markedly of the characteristics of the adulterant. It is for this reason that 30 per cent. pure rubber is generally adopted as the standard proportion, and that 40 per cent. pure rubber is required for shipboard work in the navy, the larger proportion being adopted as a special precaution on account of the necessity of absolute reliability.

The ingredients with which the rubber is adulterated differ with the various manufacturers, and in every case their composition is jealously guarded as a trade secret.

THE RUBBER INSULATION PROBLEM.

Knowing that 30 per cent. of pure rubber, containing not over 3 per cent. of extractive matter, when compounded with suitable materials and vulcanized to a proper extent gives a first-class insulating material, how can a purchaser of material, represented to be made as described above, assure himself that he is actually getting what it is represented to be, while confronted with the situation that the manufacturer will not permit any examination of the processes of manufacture?

For a long time this question remained unanswered, and in the meanwhile a new competitor to rubber appeared in the field, in the form of varnished cloth. This insulator, being composed of staple commercial articles of known stability and excellence, rapidly came into prominence, its introduction being further hastened by the constant failure of low-grade rubber compounds, with which the market was infested. The manufacturers of better grades of rubber compound then sought to protect themselves by issuing specifications, which would pass their own compounds but not the compounds made by other firms, and thereby made public a number of important facts which have been noted and combined by various engineers for the purpose of making specifications of general and beneficial use. It is these data, given out by competing manufacturers, combined with the results of experience of consumers, which constitute the basis of modern rubber compound specifications.

PROPERTIES OF RUBBER COMPOUND.

The characteristic properties of rubber compound which are available as indications of quality are given in table I, the qualities which are indicated by these characteristics being given with them.

TABLE I.

Characteristic Properties of Rubber Compound.

CHARACTERISTIC OF COMPOUND	WHAT THE CHARACTER INDICATES
Chemical	
Percentage of Rubber..	....
Percentage of Ash.....	Amount of mineral matter.
Percentage of Extract..	Dryness of rubber if percentage is small.
Mechanical	
Tensile Strength.......	Degree of vulcanization, amount of rubber, method of manufacture.
Elasticity............	Degree of vulcanization, amount of rubber, method of manufacture.
Elastic Limit..........	Degree of vulcanization, amount of rubber, method of manufacture.
Electrical	
Dielectric Strength.....	Degree of vulcanization, amount of oily extract, absence of imperfections.
Insulation Resistance..	Degree of vulcanization, amount of insulating material, method of manufacture.
Temperature Coefficient of Insulation Resistance...............	Degree of vulcanization, amount of rubber, amount of organic matter besides rubber.
Specific Inductive capacity................	[Not fully investigated.]

CHEMICAL ANALYSIS.

The chemical analysis can reveal little besides the amount of rubber, regardless of its quality. The proportion of acetone extract in the compound does not indicate the quality of rubber used, because this percentage is seldom less than five, which, were it all from the rubber, would mean nearly 17 per cent. of extract in the gum.

Besides indicating very little the chemical test may be objected to on the following grounds:

(1) It takes too long to perform when the total time consumed between delivery from the factory and return of tests from the chemist is considered.

(2) The cost of analyses is too great for regular tests.

(3) There are very few chemists sufficiently experienced in this field to undertake an accurate analysis.

It therefore appears that, as a regular acceptance test, the chemical analysis is not suitable, its only use being as a final arbiter of the proportion of rubber present.

ACCEPTANCE TESTS.

The chemical test being eliminated, except as a final resort, there remains the three mechanical and three electrical tests to consider.

Table II shows how each of these six tests indicates the five principal characteristics of rubber compound.

The effect of specifying various combinations of tests is as follows:

Tests 1, 2, 3, 4, 5, 6. Compound must contain large proportion of rubber, properly vulcanized, non-porous, and probably with a small amount of extractive matter.

(Very few manufacturers will bid on this combination.)

Tests 1, 3, 4, 5, 6. Compound will have practically the same characteristics as above.

(Almost as difficult to get bids on as the first combination.)

Tests 1, 4, 5, 6. Compound probably contains large proportion of rubber, very highly vulcanized, of good structure, but possibly a large amount of extractive matter.

(Recommended by some manufacturers for h.t. work, as the high vulcanization and high proportion of extract add to the dielectric strength.)

Tests 1, 2, 4. Practically any compound will pass this combination of tests, regardless of amount of rubber or degree of vulcanization.

(Practically all manufacturers will bid on this.)

show a tensile strength of at least 800 pounds per square inch. This figure is agreed to by practically every manufacturer of rubber compound in the United States, but the proportion of compounds which actually show this tensile strength is small.

A sample should be cut so that the ends gripped shall be considerably larger than the center, where the break should occur. The sample should be bent slightly, in every direction, before testing, in order to magnify and reveal any surface incisions which might reduce the total cross-section.

This test is one of the best of the six, when carefully performed.

SET AFTER STRETCHING.

When stretched three times its original length, a sample should show a set not greater than 18¾ per cent. after a stated time has elapsed. Although the time requires further explanation, this percentage set is agreed to by all the leading manufacturers.

TABLE II.

TEST NO.	TEST	STRUCTURE	PROPORTION OF EXTRACT	PROPORTION OF RUBBER	DEGREE OF VULCANIZA'N
1	Great tensile strength	Dense	....	Large	Normal or High
2	Small set after stretching.............	....	Small	Large	Normal or Low
3	Prompt return after stretching..........	....	Small	Large	Normal or Low
4	Great dielectric strength...............	Homogeneous	Large		Normal or High
5	Great resistance, megohms............	Dense	Small	Large	Normal or High
6	Low temperature coeff. of resistance....	....		Large	Normal or High

[Note.—The adjectives in the last four columns refer to the characteristic named at the head of the column.]

It should be noted that when bids are asked for on the basis of tests 1, 2, 3, 4, 5 and 6, the manufacturers who make a straight bid usually ask a higher price than those who suggest the omission of one or more of the tests. Sometimes a manufacturer will undertake to meet a certain combination of tests, and failing to meet one or more of these, will request the acceptance of the cable on the basis of the remaining tests. This should be carefully guarded against, as it is not the individual tests, but the proper combination of them which secures results.

The exact numerical statement of the six tests will be considered next.

TENSILE STRENGTH.

A good 30 per cent. Para compound, properly vulcanized, should

In order to guard against objections to specific tests, it should be specified that the test may be performed by the purchaser at any temperature between 50 and 100 degrees F. It should also be specified that the sample tested shall not have been submitted to any previous stretching, because a sample with a permanent set will not show much additional set when further stretched. Stretching should be steady and release instantaneous.

PROMPT RETURN AFTER STRETCHING.

Nearly all specifications which have been made public state that the set shall be measured one minute after release. This, in the writer's opinion, is too lenient, as it permits a very viscous compound to pass. Five seconds after release is sufficient time to allow, if the compound is not viscous or over-vulcanized.

DIELECTRIC STRENGTH.

See under Dielectric Stress, below, and Table IV.

SPECIFIC RESISTANCE.

The specific resistance of insulation sold as 30 per cent. Para compound varies between the enormously wide limits of 150 millions of megohms per inch cube and 4000 millions of megohms per inch cube.

From the standpoint of leakage, a mere fraction of the smaller value would be sufficient. It is, therefore, only as a test of quality that high megohms may be demanded. Differences of manufacture cause the megohms of an over-vulcanized sample of one make to be greater than the megohms of an under-vulcanized sample of another. A minimum of 750 millions of megohms per inch cube is conservative, and there is little to be gained by specifying over 1500 millions of megohms per inch cube.

The insulation resistance of a cable is derivable from the following formula:

$$M=58\times10^{-7}\times S\times\log\frac{t+r}{r}$$

where

M=megohms per mile;

S=specific resistance in megohms per inch cube;

t=thickness of insulation inches

r=radius of wire, inches;

logarithm is to base ten.

TEMPERATURE COEFFICIENT OF RESISTANCE.

The rate of change of resistance with regard to temperature should not exceed 2.6 per cent. per degree Fahrenheit. This is in agreement with the tables used by the most reputable manufacturers. The object of specifying this quantity is twofold: First, to prevent the manufacturer using any temperature correction factor which will give a figure which complies with the specifications; second, as a measure of quality of the compound as pointed out by H. G. Stott, Proc. Am. Inst. Elect. Eng., 1906.

The writer's experience very strongly confirms Mr. Stott's opinion of the value of this test.

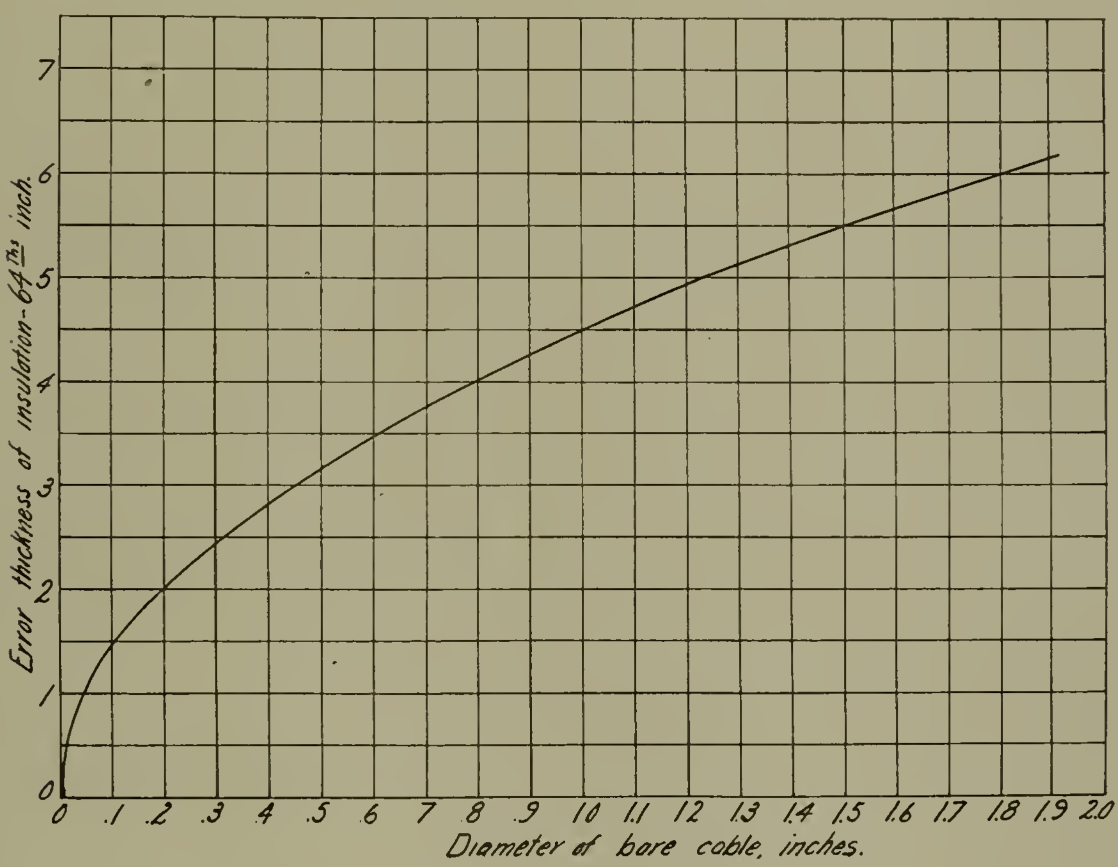


FIG. 1.

CALCULATION OF INSULATION THICKNESS.

The variety of opinion as to the proper thickness of insulation to be used shows that this matter is not treated in a scientific way. The method of calculating the proper thickness, given below, while probably susceptible of improvement is certainly much better than the haphazard guessing often employed.

THICKNESS OF INSULATION.

The thickness of insulation to be placed on a wire is governed by three features:

1. Errors in size of wire, eccentric situation of wire in the insulation, and similar irregularities.

2. Insulation not to be strained by application of test voltage.

TABLE III.

TABLE OF ERROR THICKNESS

SIZE OF WIRE		ERROR OF THICKNESS
14		.018
12		.020
10		.022
8		.025
6		.028
4		.032
2		.036
1		.038
0		.040
00		.042
000		.045
0000		.047
250000		.053
500000		.063
750000		.070
1000000		.075
1250000		.080
1500000		.083
1750000		.086
2000000	concentric.	.089
2000000	rope.	.095

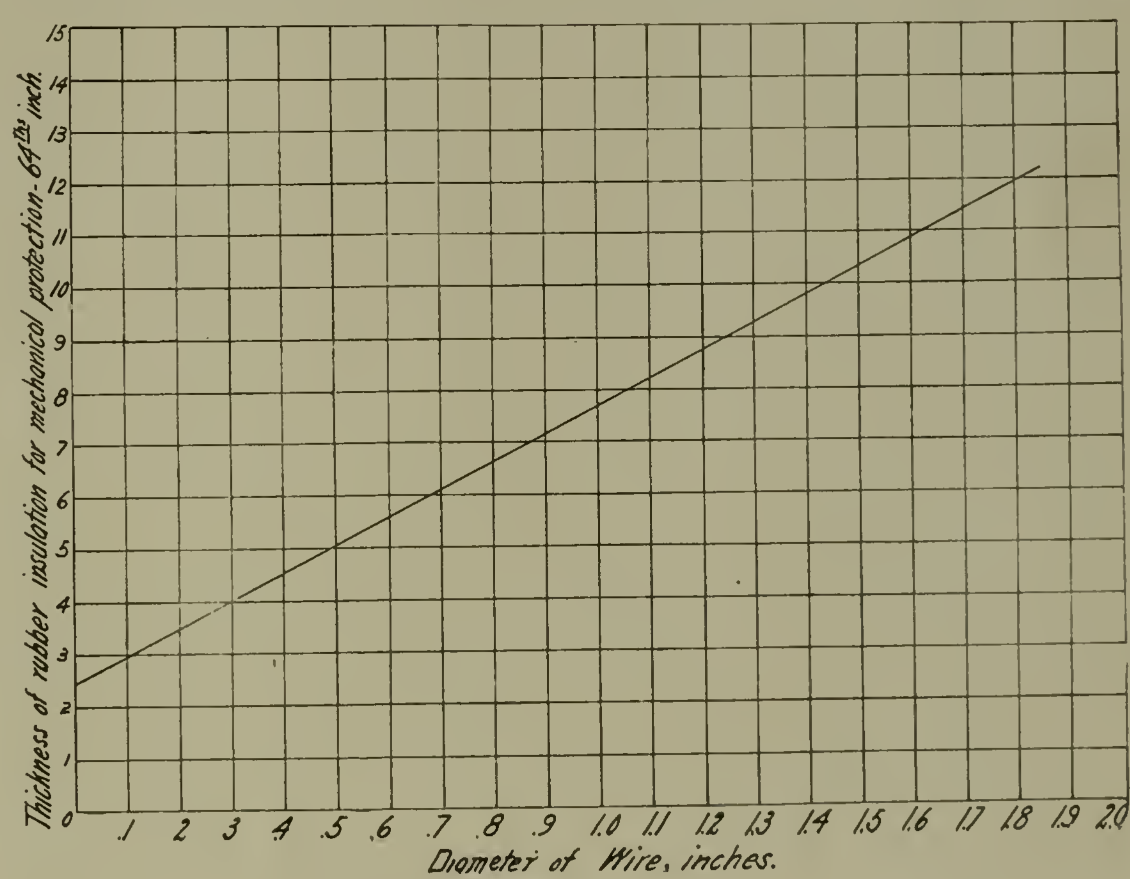


FIG. 2.

3. Insulation to be thick enough to have mechanical strength.

ERROR THICKNESS.

The thickness of insulation required to make up for errors and irregularities of manufacture may be termed the *"Error Thickness."* Fig. 1 shows how this error thickness is found in practice to depend on the diameter of the wire. This curve very closely follows the following equation:

Error Thickness (64ths. inch)

$$=\sqrt{2 \times \text{Diameter of wire, inches}}$$

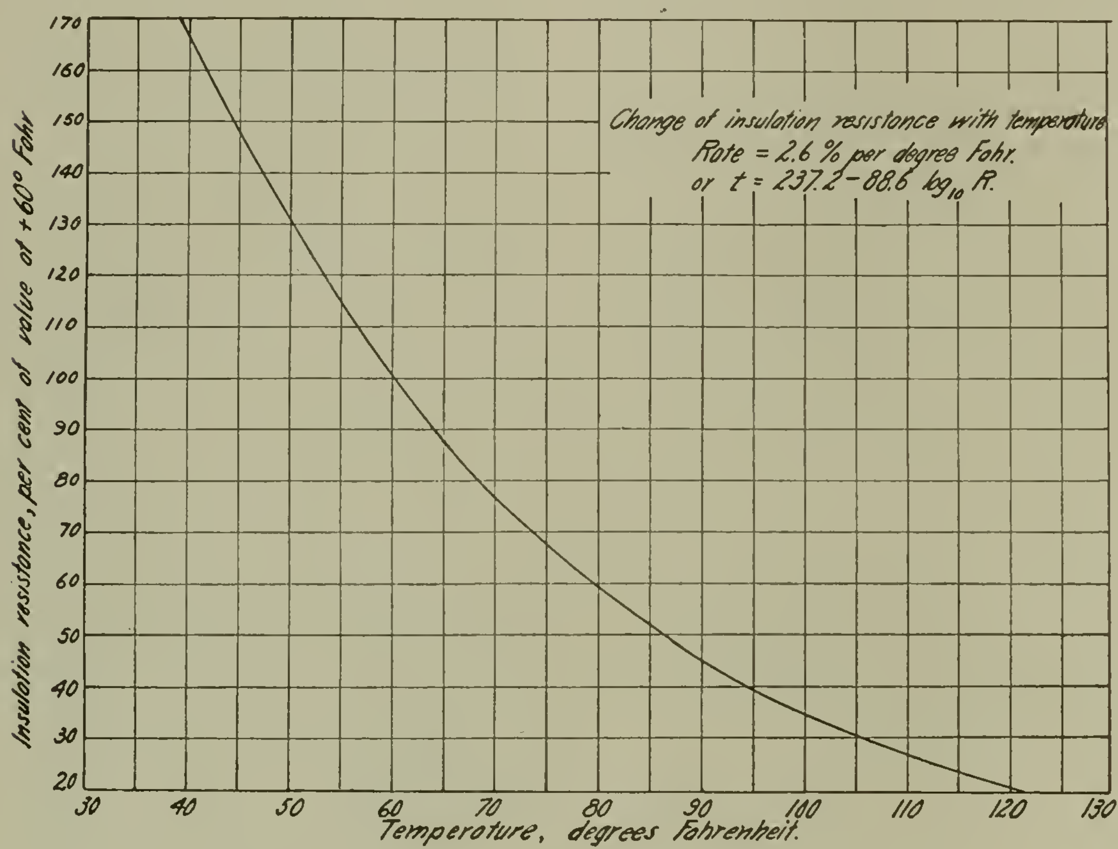
$$=2\sqrt{\text{Radius of wire, inches.}}$$

Table III is based on the curve of Fig. 1.

The electric force around a cylindrical wire, however, is not uniform, the lines extending radially from the wire to the outside of the insulation. The density of the force lines is therefore greater at the surface of the wire than at the outside of the insulation. This explains the well-known fact that small wires insulated for high potentials often show a disintegration of the inner layers of insulation without any visible defect on the outside. In this case

$$F=\frac{.434V}{r \log \frac{(t+r)}{r}}$$

where r is the radius of the wire,



CURVE SHOWING CHANGE IN INSULATION RESISTANCE DUE TO HEAT.

DIELECTRIC STRESS.

When a high potential is established across the insulation of a cable, the insulation is subjected to a strain which depends upon the degree of concentration of electric force. When this concentration reaches a certain value, the insulation will no longer be able to stand the strain and will break down. It will not necessarily be punctured, but will be disintegrated only where the concentration of electrical force has been excessive. For purpose of analysis, it is usual to represent the intensity of electric force by the density of imaginary lines of force stretching radially from wire to sheath.

Let F=electric force or dielectric strain

V=Test potential, kilovolts

t=thickness of insulation, inches, over error thickness.

then $F=\frac{V}{t}$ where the electric force is uniform.

inches, and the logarithm is to the base ten.

This gives: $V=2.3026\ F.r.\log.\ \frac{t+r}{r}$

A stranded cable does not exactly follow the same law as a solid wire, but the error, introduced by assuming a solid wire of the same over-all diameter is not very great for the usual sizes.

Table IV shows the value of F, the dielectric stress, expressed in kilovolts per inch.

Owing to the individual wires of a multiplex cable being pressed together in assembling, the voltage test between cables should be slightly less than double that on a single cable. Ten per cent. is taken as a conservative amount for the loss due to this.

On three-phase cables the maximum surge voltage between conductors can only be 1.734 times the voltage to ground. Allowing for squeezing, due to assembling, 1.7 times the test voltage to ground may be taken as the test voltage from wire to wire.

TABLE IV.

DIELECTRIC STRESS.

CONDITION	KILIVOLTS PER INCH
Common working stress	40 to 43
Conservative testing stress	95 to 100
High testing stress	125 to 135
Breakdown*	150 to 300

* This depends entirely on the degree of vulcanization. The lower figure represents tests on one of the best grades on the market; the higher figure represents an over-vulcanized compound.

ELECTRICAL THICKNESS.

The error thickness being known, the *electrical thickness*, or thickness required to withstand the electrostatic stress, may be calculated with the aid of the logarithmic formula, above.

The thickness of insulation adopted for potential differences up to about 1000 volts is determined solely by mechanical considerations, the dielectric stress not being concerned.

MECHANICAL THICKNESS.

The error thickness and electrical thickness of insulation are often insufficient for mechanical reasons. Fig. 2 shows the minimum thickness of insulation which is permitted by mechanical considerations. Unlike the electrical thickness, which is added to the error thickness, the mechanical thickness is a total figure which includes everything. This graph, while based on average practice, may not meet the requirements of some engi-

TABLE V.

BASED ON:

Specific resist. of rubber = 1100 x 10′ meg. per in cube.

Working dielectric stress = 42.3 kilovolts per inch

Testing dielectric stress = 96 kilovolts per inch.

SINGLE CONDUCTOR CABLES.

5000–7000 volts alternating current, single phase.

9000–12,000 volts alternating current, three phase.

Size.	Str'ds.	Insulartion Wall 64ths inch.	Test Voltage Alternating.	Meghoms per mile.
4 B.&S.	12	25	15,000	4,100
2 "	10	22	15,000	3,300
1 "	10	20	15,000	2,000
0 "	10	10	15,000	2,600
00 "	10	18	15,000	2,400
000 "	10	18	15,000	2,000
0000 "	10	18	15,000	2,000
250,000 C.M.	37	17	15,000	1,800
500,000 "	61	17	15,000	1,400
750,000 "	61	17	15,000	1,200
1,000,000 "	01	17	15,000	1,060

TEST VOLTAGE ON MULTIPLEX CABLES.

Between conductors and ground.	As specified in tables.
Between conductors, direct current and single-phase cables.	90 per cent. greater than in table.
Between conductors, three-phase cables.	70 per cent. greater than in table.

(Megohms to be measured before assembling conductors.)

[The thickness of insulation above is settled entirely by electrical consideration, the amount of rubber being ample for mechanical purposes. The insulation thickness expressed in nearest 64ths, test voltage to nearest thousand, and megohms to nearest hundred.]

neers, and should therefore be carefully examined before it is used.

SUMMARY HOW TO CALCULATE THICKNESS OF INSULATION.

T=Total thickness of insulation, 64ths inch.

R=Radius of wire, inches.

$t=T-2\sqrt{R}$

t must be such that,

$\log(t+R) = \frac{.434V}{w.r} \times \log r, \ldots\ldots (a)$

where V=test kilovolts.

w=dielectric strain in kilovolts per inch at test volts.

The minimum permissible value of T is,

$T=2.5\times 10.6\ R \ldots\ldots\ldots\ldots\ldots (b)$

Hence, if equation (*a*) gives a lower value than equation (*b*), then the latter value should be used.

Explanation:—The thickness of insulation required to make up for irregularities of wire, expressed in 64ths inch, $=2\sqrt{R}$. The additional thickness required for insulation is given by (*a*). The amount required for mechanical strength is given by (*b*).

Transformer Boosters

BY C. J. SPENCER.

THE use of an ordinary transformer for boosting a voltage on the primary circuit is a trick well known to central station men, but they do not generally understand that the insulation of a transformer thus connected is subjected to a strain that it was not designed to carry and that will sooner or later develop a ground and cause trouble on the line.

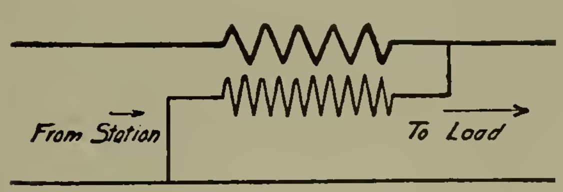


FIG. 1.—DIAGRAM OF CONNECTIONS.

One method of connecting the ordinary transformer for this purpose is shown in Fig. 1. This is an adaptation of an ordinary transformer to perform the duties of a potential regulator. The low-voltage winding is connected in series with the line and the high-voltage winding is connected across the line. It will readily be seen that the action is to raise the line voltage when the load exceed the magnetizing current, and this increase of voltage with unity power factor is approximately proportional to the load in amperes.

Transformers thus connected have performed efficient service on lines supplying incandescent lamps, and the boosting effect is quite appreciable with loads having power factors as low as 80 per cent.

The selection of a transformer for

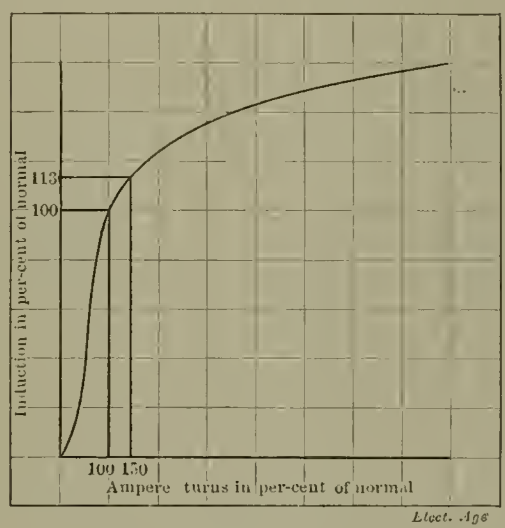


FIG. 2.

this service depends largely upon its design. A transformer which is normally worked at a high point on the magnetization curve gives but a slight increase of voltage with increase of load, while a transformer which is normally worked at lower magnetic densities gives voltages proportional to the current flowing in the secondary.

Fig. 2 shows the effect of increasing the amperes in a definite number of turns beyond the normal point marked X. The induction soon reaches a point when it increases but slowly as the amperage is increased. The induced voltage depends on the induction, and in consequence increases rapidly at first and then slowly.

A transformer must be selected which operates satisfactorily at the maximum voltage to which it is expected to raise the line voltage. If the line voltage is to be raised to 2500 volts, the transformer should be wound for 2500 volts.

This point is frequently overlooked. The central station has supply lines of 2000 volts normal potential and one of the standard 2000-volt transformers is connected as a booster. A voltage of 25 per cent. or more higher than normal is delivered by the primary winding and, unless the insulation has a large factor of safety, the primary develops a short circuit between two adjacent turns, thus throwing these turns out of service and increasing the volts per turn on the rest of the winding. While all transformers are made to withstand a voltage considerably higher than normal, for a short time, the continued application of a high voltage weakens the insulation.

Another portion of the insulation which is worked at an unusual voltage is the insulation between secondary and iron. Most transformers are now made to withstand a high voltage between secondary and iron in order to withstand the voltage impressed at this point with a grounded neutral. However, while the manufacturers make their transformers with ample insulation, this insulation should not be abused simply because it is there. It should be used as a safeguard and protection.

The loss of customers incurred by the uncertain service which is sure to follow when crude methods are adopted for distribution of electric energy, soon diminishes the receipts far beyond any gain in first cost obtained by utilizing the material at hand

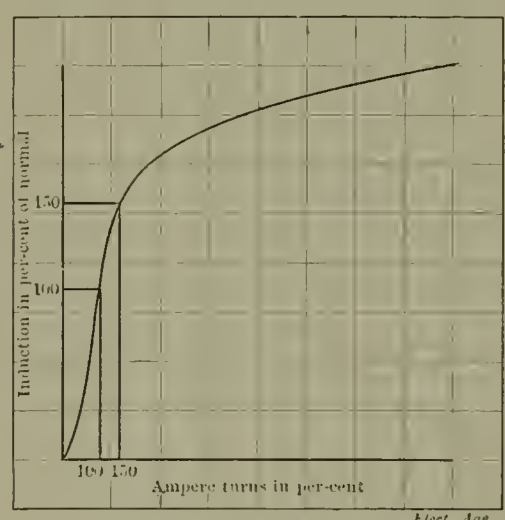


FIG. 3.

for purposes to which it was not designed.

Potential regulators are made for the regulation of feeder voltages. The iron and windings are proportioned for the correct rise of voltage with rise of current, and the insulation is designed to withstand the voltages impressed by this particular service. While the external appearance of the transformer supplied as a potential regulator may not be greatly different from the external appearance of the standard transformer, the interior insulation of the two pieces of apparatus will be found to differ greatly.

Three-Phase Four-Wire Distribution

H. L. WALLAU

Engineer, Cleveland Illuminating Company

THE decrease in kilowatt cost of transformers of increasing size, and the consequent reduction of fixed charges, together with the increased all-day efficiency, makes it imperative to establish alternating-current secondary distributing mains instead of supplying each consumer from individual transformers. To illustrate, a 25-k.w. transformer costs per k.w. about 38 per cent. of a 1-k.w. transformer, while its all-day efficiency, based on full-load 4 hours and no-load 20 hours, is about 14 per cent. higher than that of 1-k.w. transformer.

Successful distribution of current from low tension mains for incandescent lighting depends upon the regulation of the system. By regulation is understood the variation in voltage between no-load and full-load at that point on a low tension main at which the greatest drop occurs. This variation in voltage should not exceed 5 per cent. and whenever possible should be less.

When the voltage of an incandescent circuit drops 2 per cent. below normal, the candle-power of the lamps drops approximately 10 per cent. When a lamp burning on a normal circuit has reached 80 per cent. of its initial candle-power, its useful life is considered ended. For this reason 98 per cent. of normal voltage is as low as it is advisable to allow pressure to drop at times of peak load. With 5 per cent. regulation this brings the no-load voltage up to 103 per cent. At this voltage an incandescent lamp burns at 118 per cent. of candle-power and has its life shortened 52 per cent. Since the number of lamps burned during times when the voltage of the circuit is above normal is comparatively small, no great loss results.

The regulation of an alternating secondary system is dependent upon the drop in the primary mains, in the transformers and in the secondary mains (all of which vary with the power factor of the load), the pressure at the high-tension feeder terminal being assumed to be maintained constant by regulators used in conjunction with compensated volmeters.

The power factor of the load has an important influence on regulation; for instance, a 50-k.w. transformer may have a regulation of 1.1 per cent. at 100 per cent. power factor, and a regulation of 3.2 per cent. at 60 per cent. power factor.

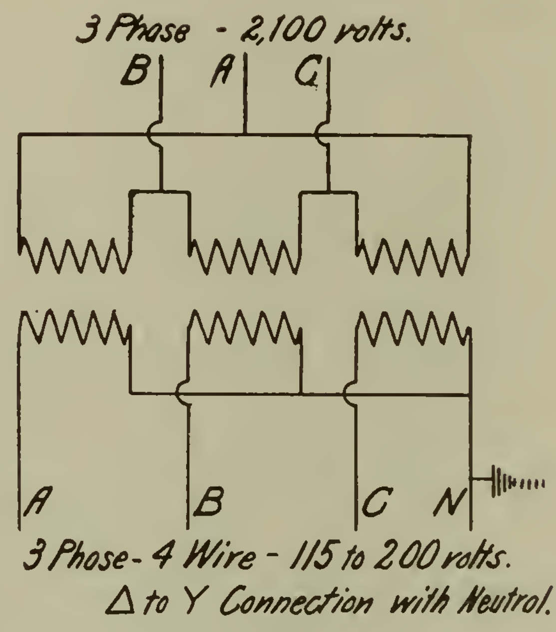
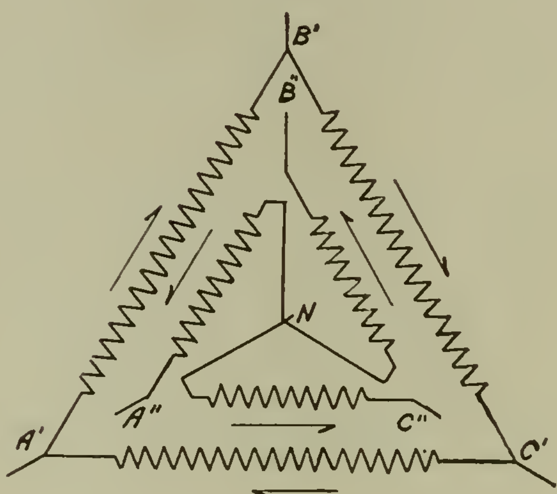


FIG. 1.



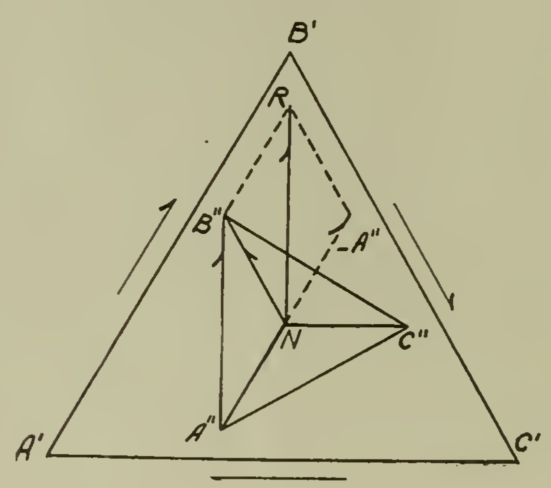


FIG. 2.

In designing a secondary system it is essential to strike a balance between the number of transformers used and the amount of copper required to distribute the load from the transformers selected, since the fewer the units, the greater the distance between feeding points, and consequently the greater the weight of secondary copper required.

In selecting the k.w. transformer capacity required, the connected load of various classes of service must be known and the proper percentage of demand of each class figured. For example, commercial lighting may have a demand of from 80 to 100 per cent. of the connected load, while residence lighting may vary from 30 to 40 per cent. and apartment work from 40 to 60 per cent. of the connected load.

If a commercial district is being developed and a day power load sought as well as a lighting load, it must be borne in mind that at certain seasons the power and lighting loads will lap and that at such times the voltage may drop below the prescribed minimum unless this consideration has been taken into account in the design of the system.

Cost considerations make it desirable to operate the transformers at overloads during the peak load, but in selecting the capacities it must be remembered that the percentage losses increase about twice as fast as the percentage load up to about 25 per cent. overload, and faster above 25 per cent. overload.

Commercially, the best regulation at the lowest fixed charge per annum is desired of any secondary system. The primary and secondary mains are usually designed for a regulation of 1 per cent. with a balanced load of unity power factor, leaving 3 per cent. to come and go on for transformer regulation and the lowering of the power factor due to inductive load.

The three-phase four-wire system looms up very promisingly in this connection; its high transmission efficiency lends itself readily to an economical design.

One of the most common ratios of transformation is from a 2100 volt primary to a 115 volt secondary, a delta to Y connection being used, with the neutral point grounded. This arrangement is shown in Fig. 1. It yields 115 volts between any phase and neutral and 200 volts between phases. See Fig. 2.

This affords a good voltage for incandescent and arc lighting and suitable voltage for either single or three-phase power work, also a voltage on which Nernst lamps may be operated.

It will be noticed on looking at the diagram of pressure that the voltage between phases is shifted by the transformation through an angle of 30° with reference to the primary; also that this resultant voltage *N R* between phases *A* and *B* is the difference between *N A* and *N B*, since in passing from *A* to *B* we pass against the arrow in the first coil and with the arrow in the second. The resultant delta of *e. m. f.'s* may also be represented by the triangle *A″ B″ C″*.

Let three transformers having a ratio of transformation of one-to-one be connected on one side, each independently of the others, to a separate phase of a three-phase system and let their secondaries be independent (Fig. 3).

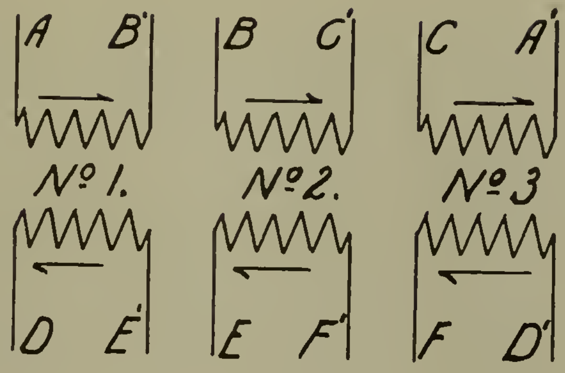


FIG. 3.

Let us assume the voltage across the primary be to 100 per cent. under all conditions of loading, the secondary voltage to equal the primary at no-load.

Let the resistance drop of each transformer and secondary main be 3 per cent. and the reactive drop 8 per cent. both at full load and unity power factor.

Assume various conditions of loading and note the regulation.

Case 1. Transformer No. 1. Loaded with full load in current in phase with no-load *e. m. f.*

Case 2. Transformer No. 2. Loaded with full load in current lagging 30 degrees behind no-load *e. m. f.*

Case 3. Transformer No. 3. Loaded with full load current lagging 45 degrees behind no-load *e. m. f.*

Fig. 4 shows these cases. In the diagrams 1-3 represents the no-load *e. m. f.*, 1-2 the current in phase and magnitude, 3-4 the resistance drop *I R*, 4-5 the reactive drop $2\pi f L I$, 3-5 the resultant impedic drop and 1-5 the pressure at the load terminals in phase and magnitude.

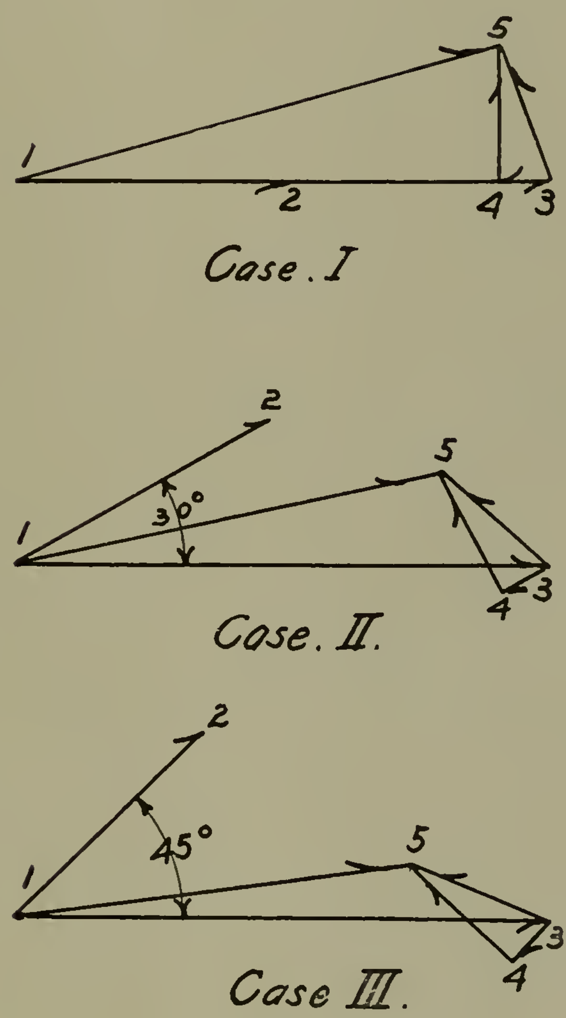


FIG. 4.

The diagrams show clearly the increased drop due to decreasing power factor with the same current. Had the wattage been maintained constant the drops would have been much greater.

Case 4. Now, suppose wires *D′*, *E′*, *F′* to be combined in one wire. This produces a Y connected secondary. Since no change has been made in loads or voltages we can construct a diagram showing the regulation as a four-wire system, Fig. 5.

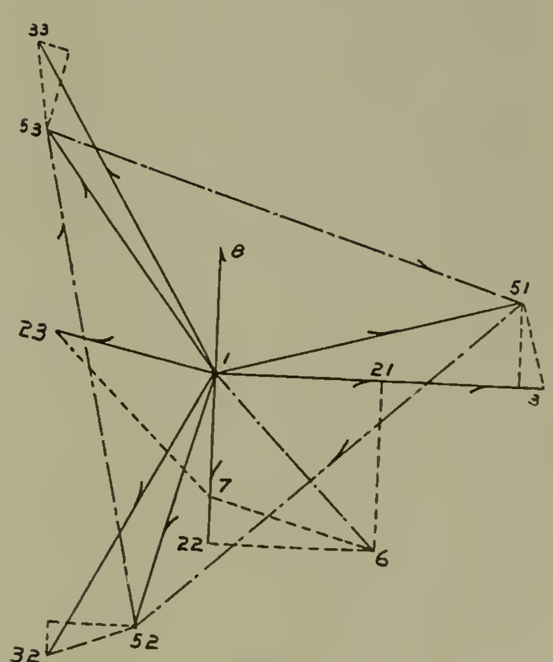


FIG. 5.

The no-load voltages are, of course, 120 degrees apart and are represented by 1-31, 1-32, 1-33. In Fig. 5 the same system of numbering is used as in Fig. 4, with the addition of a suffix 1, 2 or 3, to show which particular values are referred to, thus 1-31 represents 1-3 Case 1, 1-22 represents 1-2 Case 2, etc.

The no-load triangle of *e. m. f.* would be represented by 31-32-33, the loaded triangle of *e. m. f.* is 51-52-53. If only one transformer had been loaded, say, No. 2, the loaded triangle of *e. m. f.* would have been 31-52-33. If a single phase 200 volt load had been taken off, the triangle of *e. m. f.'s* would have had two long sides and one short one, the amount of unbalance and phase displacement depending upon the power factor of the load.

Other conditions may arise when two phases are carrying a heavier load than the third, giving a triangle of *e. m. f.'s*, in which one side is greater and one side smaller than the side representing the drop between the heavier loaded phases.

Referring to Fig. 3, it will be seen that the currents at *D*, *E* and *F* all flow away from the coil, hence their resultant in the neutral wire is evidently the sum of 1-21, 1-22 and 1-23, reversed. This is shown by 1-8 in phase and magnitude.

It is to be noted, therefore, that a balanced three-phase load means more than a balance in amperes per phase, the relative displacements of the currents from their respective *e. m. f.'s* must be the same.

Now suppose *B′* joined to *B*, *C′* to *C*, *A′* to *A*, Fig. 3, what currents will flow in *A*, *B* and *C*? It is evident that the resultant current in *B*, for instance, will be the difference between the original current in *B*, and the original current in *B′*. The original current in *B* was the primary current in transformer No. 2, and this we know to be equal and opposite to the secondary current of that transformer. Fig. 6 shows the Y of currents, 0-21, 0-22, 0-23, 0-*B* representing the difference between 0-22 and 0-21, or the current in phase *B*, likewise 0-*C* and 0-*A* show the resultant currents in phase *C* and *A*, both in phase and magnitude.

It can readily be shown that the current in

Phase *A*=2 I Cos. 7.5 degrees=1.98 *I*
Phase *B*=2 I Cos. 45 degrees=1.41 *I*
Phase *C*=2 I Cos. 37.5 deg.=1.59 *I*
when *I* equals the current flowing in the coils.

Having determined the value of the primary currents per phase, it is of interest to determine their relation with reference to the triangle of balanced *c. m. f.'s*, which it was agreed to maintain across the primary coils of the transformer.

1-2-3 represents the delta of *c. m. f.'s* maintained across the primary, and *O-A, O-B, O-C*, the Y of currents in magnitude and phase.

Now let us assume the three transformers to be located at the feeder terminal, the feeder having resistance and reactive drop. The *Y* of potential maintained is represented by 0-31, 0-32, 0-33.

The resistance drops are shown 1-4, 2-6, 3-8, the reactive drops by 4-5, 6-7, 8-9.

The delta of *c. m. f.'s* to be maintained on the line side of the regulators is shown by 5-7-9. The regulator boosts assuming the bus voltages to be equal to 1-2, 2-3 and 3-1 are shown in phase and magnitude by 1-5, 2-7 and 3-9.

These cases have been worked out to show some of the practical difficulties arising from phases out of balance.

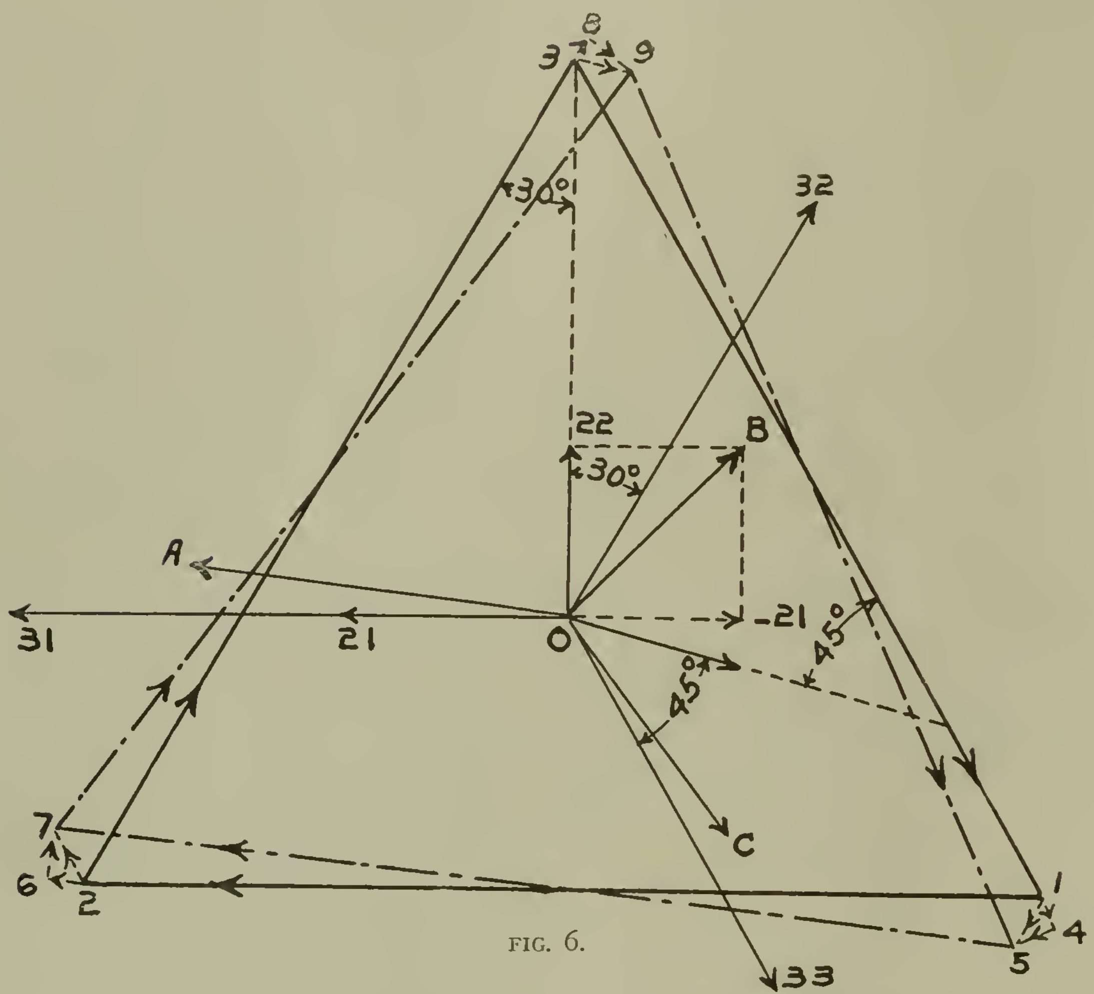


FIG. 6.

The chief difficulty in operating a four-wire system of distribution is that of maintaining a balance, or at least limiting the out-of-balance load to an amount that will not cause a drop in any primary wire of greater magnitude than the boosting capacity of the regulator, nor cause an excessive drop in any secondary conductor with a balanced primary voltage.

Small installations are naturally wired on a two-wire system, requiring a service consisting of a one-phase wire and a neutral; larger ones are wired three-wire, necessitating the bringing in of two-phase wires and a neutral, the largest are wired four-wire. All power and light installations require the four wires.

A three-wire service, consisting of two phase wires and a neutral, cannot be metered on a three-wire meter; two separate single-phase meters must be installed. A four-wire service requires three meters.

A secondary system carrying a load of 500-k.w., distributed among 400 consumers, with connected loads carrying from ¼ to 50-k.w., is by no means an easy system to balance, nor to keep in balance as it grows. It is expensive, since it means changing taps to individual consumers all along the line to readjust conditions when they become bad. If the secondary is underground it is much harder to balance, since phase wires must be tested out and tagged at each service, and the cost is almost prohibitive.

Another thing against the four-wire system is the growing use of Nernst lamps, and mercury rectifiers for automobile charging. Nernst lamps are not satisfactory on 200-volt circuits. The length of the glower has to be so reduced for operation on this voltage that their candle-power is materially cut down, compared with the candle-power of a similar lamp on a 230-volt circuit.

It is impossible to prevent the man using 200-volt Nernst lamps from comparing the illumination which he gets with that of some other consumer on a 230-volt circuit.

Another source of trouble, though not an excessive one if properly installed, is caused by grounds on the phase wires, which disturb pressure conditions.

All things considered, a three-wire single-phase system of distribution, with a fourth or teaser wire to supply three-phase current for power, is preferable to a four-wire system.

The regulation across the lighting phase can be looked after carefully, that across the two additional power phases need not be closer than 10 to 15 per cent.

It is far easier to keep such a system balanced by connecting smaller sections across the various phases. When balancing is to be done a few changes make a marked difference, as 50 to 100-k.w. may be transferred at a time.

The three-wire system with teaser has all of the advantages and none of the disadvantages of the four-wire system, save only in transmission economy.

Its transmission economy is, however, sufficiently high to allow of economical low tension distribution, as evidenced by the three-wire direct-current systems all over the country.

Miller's Chart for Plotting Speed-Time Curves

THE computation of speed-time curves is the first step in the preparation of run sheets, which are a necessary preliminary in the settlement of electric traction problems. This computation is a lengthy one at best, owing to the large number of variables which must be taken into account in each run to determine the net acceleration of the motors. The tractive effort required to overcome the train resistance varies with the speed, but not according to any integral power of it. The particular curve is a matter to be settled according to the judgment of the engineer.

There are a number of formulas for this purpose, over fifty having appeared in different technical papers within the last few years. The tractive effort required to overcome grades is independent of the speed, its value being 20 pounds per ton for each one per cent. of grade. Some experiments made by the Chemin de Fer du Nord, of France, under the direction of Monsieur Barbier, have indicated that the resistance and acceleration due to grades has a value of 18 pounds per ton for each one per cent. of grade, due possibly to the fact that the transition from grade to tangent is made by a vertical curve. Curves can be considered as grades against traffic, and allowed for in the same manner, the usual allowance being about 0.8 pounds per ton for each degree of curvature; that is, one degree of curvature is equivalent to an up grade of 0.04 per cent. The foregoing refers entirely to the resistances to be overcome. The tractive effort of the motor varies inversely with the speed at a constant voltage, and the algebraic difference between this tractive effort and the train and grade resistance is available to accelerate the train. This acceleration may be either negative or positive.

As a preliminary it is necessary to assume a motor equipment for a train of a given weight, the selection of this equipment being facilitated by the use of tables and curves which can be secured from the builders of motors. These supply the characteristic curve of the motors and the gear ratio; the diameter of the truck wheels and the line voltage are known; from this information and the profile and alignment of the road the run sheets can be computed.

Messrs. Mailloux, Valentine and others have devised charts to be used in the computation of speed-time curves which are conducive to accuracy and materially reduce the time required for such work. Both of these methods have been extensively described, and the disadvantage of each is due to the necessity for a graphical subtraction, by the use of dividers, to obtain the net acceleration effect available. The accompanying charts, devised by Mr. W. C. Miller, Jr., formerly of the engineering staff of the New York Central Railway and now engaged with the Southern Pacific Company in its electrification work at San Francisco, are designed to obtain the net acceleration direct. In plotting these charts it is only necessary to determine and plot to scale the net acceleration for differ-

FIG. I.

ent speeds of the equipment selected, on a level track or zero grade, on a chart whose co-ordinates are the grades and accelerations, the former being given as percentage values, the latter in miles per hour per second. The slope of the lines shown at Figs. 2 and 3, representing the net accelerations available at different speeds and grades, are obtained by computing the net acceleration at some one speed for two different grades, usually the maximum negative and positive grade found on the profile. These values are plotted on the chart and connected by a straight line; the accuracy of this computation is checked by the passage of this line through the point on the zero grade line previously plotted. The acceleration lines for the other speeds are then drawn parallel to this line.

In computing the net acceleration the algebraic sum of the following quantities: the tractive effort of the motor; the resistance due to grade, either positive or negative; and the train resistance, according to the selected formula, this being a negative quantity; is divided by the acceleration constant. This acceleration constant is the energy required to accelerate one ton at the rate of one mile per hour per second, and for accurate work it is necessary to increase this constant to cover the effect of the rotating parts.

The increment of acceleration between the sloping speed lines increases as the speed decreases and is proportional to the portion of the tractive effort speed curve, between different speeds, projected upon the tractive effort axis, shown in Fig. 1. Three charts are required for each equipment, that for tractive effort, Fig. 1, upon which are plotted the curves for the current required and the tractive effort for the motor equipment under the assumed conditions; and the two charts for acceleration values, one for series, the other for multiple running.

In use the value of the tractive effort required to overcome the train resistance is indicated on each of the sloping lines, and for convenience a curve is sometimes plotted, indicating the descending grade required to balance the train resistance. In Figs. 2 and 3 this curve is marked "coasting constant speed."

Miller's chart, like those of Mailloux and Valentine, is not used during the controller period, that is, during the portion of the run during which the current passes through the controller resistances; but it becomes of service when the motors are operating on the line voltage, connected either in series or in parallel. The following example illustrates the use of the chart; the starting current of the motor is 290 amperes, which corresponds to a speed of 9 miles per hour on the series notch of the controller or

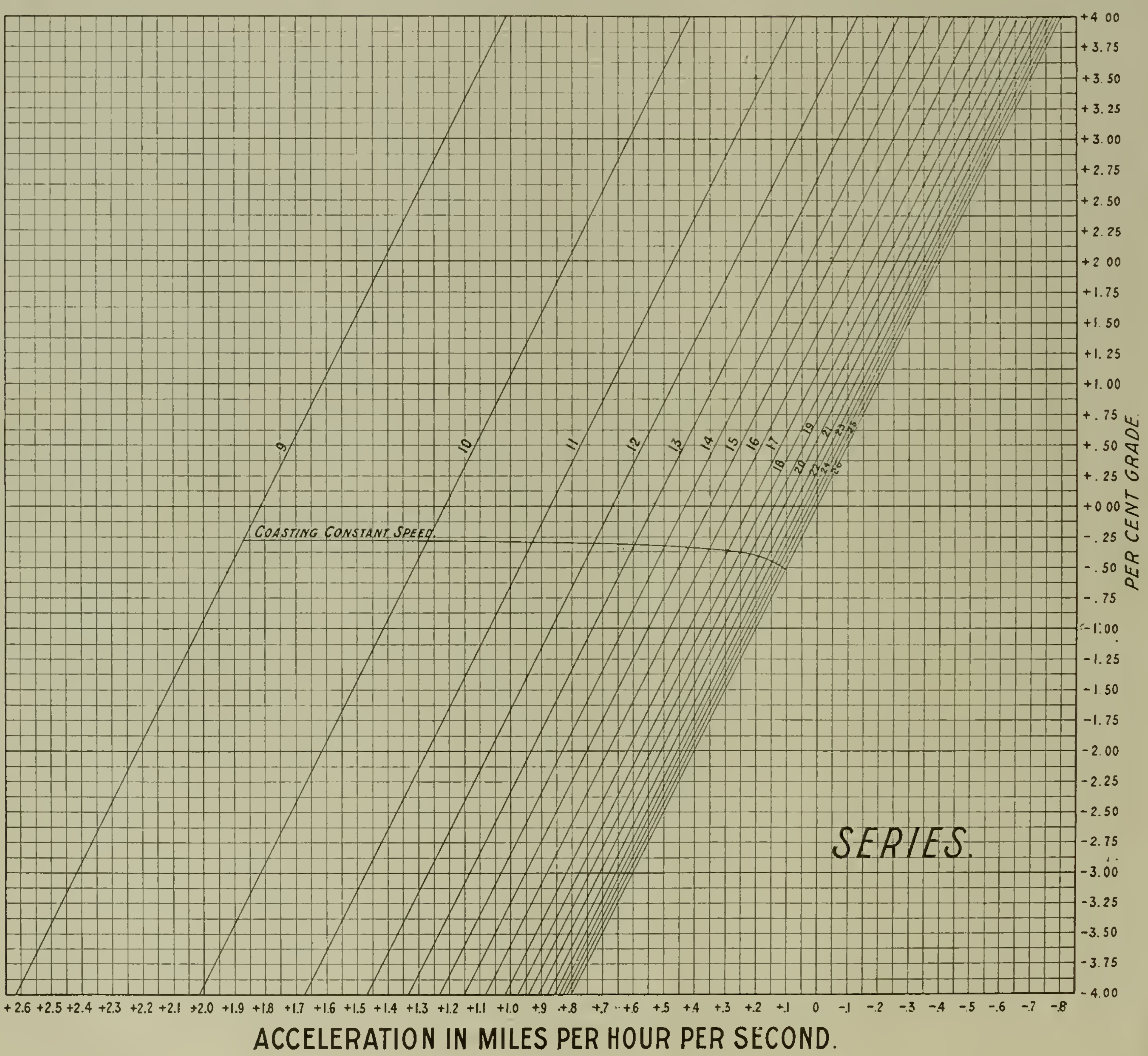


FIG. 2.

18.7 miles per hour with the motors in multiple. The portion of the run during the controller period will not be considered, as it is the same for all methods. The speed of the train on reaching the period when the motors are either in series or in parallel on the line voltage is known, as are also the length and percentage of grade and the degree of curvature of the track, which appear upon the log sheet used to record the computations, the latter in the shape of a total equivalent grade. The intersection of the sloping speed line with the equivalent grade is found upon the chart and the corresponding acceleration in miles per hour per second is read direct. Assume that the start was made on a one per cent. down grade and the motors reach the line voltage in series at a speed of 9 miles per hour; the net available acceleration tending to increase the speed of the train will be 2.02 miles per hour per second. The distance traveled while the motors were on the controller is deducted from the length of the grade, and it is therefore known how much of the grade remains to be covered. An average speed for this distance is assumed, say 13 miles per hour, thus giving a total increase in speed of 8 miles per hour on this portion of the run. From the chart it is found that the available acceleration on a one per cent. grade at this average speed is +0.73 miles per hour per second. The time interval required for this increase in speed will be $8 \div 0.73 = 11$ seconds. The distance traveled in this interval will be $13 \times 1.467 \times 11 = 210$ feet. In case this distance agrees closely with the point where the grade changes a new computation is begun in a similar manner for the next section of the track. A very short experience with this chart enables the computer to become expert at assuming the average speeds to suit the conditions of grade, alignment, etc. The distances plotted on the log and run sheets may vary slightly from those shown on the profile, but it is advisable, in accurate work, to keep this difference within the number of feet traveled in one half second; a larger amount of leeway being permissible on less accurate computation.

Miller's chart can be readily converted to suit trains in which the weight per motor varies from that for which the chart is computed by the use of a pair of dividers, though this method is not to be recommended for accurate work.

This chart has been extensively used in working out run sheets and proved to be the most rapid method for making such computations by the point to point method. It is used by the electrical engineers of the New York Central and Hudson River Railroad in their work of this character.

The chart, Fig. 1, is of use in plotting the curve showing the current consumed at the different portions of the run and is so clear that a detailed explanation is unnecessary. It will be seen that the computation of speed-time curves is greatly simplified by the use of Miller's chart.

This article has been purposely limited in its scope to cover only the method of constructing and using the chart, as the general subject of speed-time curves has been exhaustively treated in the Transactions of the American Institute of Electrical Engineers and in the technical press. Considerable information in regard to motors and equipment is obtainable in the bulletins of the manufacturing companies. The following list of references may be of use to those who desire to study the matter more fully.

Speed-Time Curves, C. O. Mallioux, June 19, 1902 Transactions, A. I. E. E.

Speed-Time Curves, C. T. Hutchinson, Jan. 24 1902, Transactions, A. I. E. E.

Speed-Time Curves, C.T. Hutchinson, Oct. 23, 1903, A. I. E. E.

Speed-Time Curves, F. W. Carter, June 30, 1903, Transactions, A. I. E. E.

Speed-Time Curves, Valentine, *Street Railway Journal*, vol. 20, page 303.

Speed-Time Curves, L. H. Freudenberg, *Electrical World*, vol. 42, pages 96 and 219

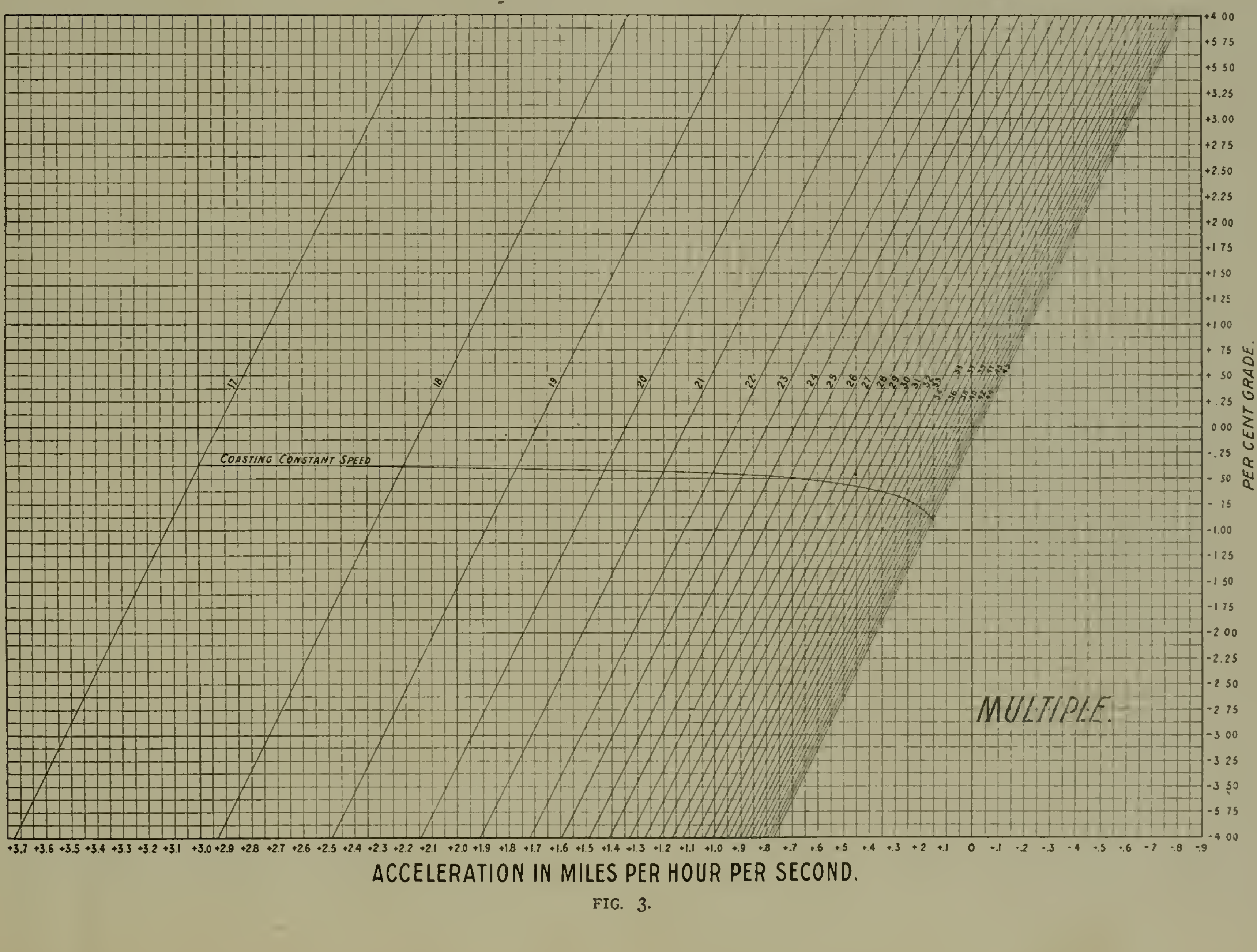


FIG. 3.

Power Factor Measured by Wattmeter Readings

THE usual method of metering polyphase power is by means of a wattmeter having two single-phase wattmeter elements mounted on one shaft and registering on one dial, that is, by the polyphase wattmeter. This type of meter as developed by one of the large manufacturing companies gives results that amply repay for its installation. Owing to the rush of increasing business, central stations are not always prepared for new customers and must utilize apparatus in stock for purposes to which it is not adapted. These conditions have led to a very general adaptation of single-phase wattmeters to the measurement of polyphase power.

Two single-phase wattmeters are connected in a three-phase circuit, each with its series coil in series with one wire and its shunt coil between that wire and the wire not connected to the series coil of the other meter. (See Fig. 1.) When the load is balanced, the sum of the readings of the two meters gives the amount of electric energy delivered.

The two meters record the same amount of energy when the power factor of the circuit is unity. With power factors less than unity, one meter runs faster than the other and this difference in readings becomes greater and greater down to a power factor of 50 per cent., when one meter stops. At power factors below 50 per cent., one meter reverses, thus deducting from the kilowatt-hours previously recorded. The ratio of the readings of the two meters corresponds to a definite power factor. Thomas M. Gibbes submits a chart, Fig. 2, which gives this relation in the form of a curve from which the average power factor of an installation can be determined by means of the readings of the wattmeters which measure the electric energy delivered to that installation.

One of the wattmeters records an increase in total kilowatt-hours registered over that at the previous reading. The other wattmeter may or may not record an increase in kilowatt-hours, depending on the power factor of the load. A reverse reading is of rare occurrence, though provision has been made for such cases by extending the curve to include all power factors. The wattmeters have been designated as Nos. 1 and 2 for convenience in reference. No. 1 is that wattmeter which gives the highest reading.

The method of finding the power factor of the load is to find the point on the curve where the straight line, drawn to represent the ratio of the two readings, intersects the curve. For instance, wattmeter No. 1 reads 700 kilowatt-hour and wattmeter No. 2 reads 350 kilowatt-hour. The ratio of these readings is represented by the sixth oblique line counting from

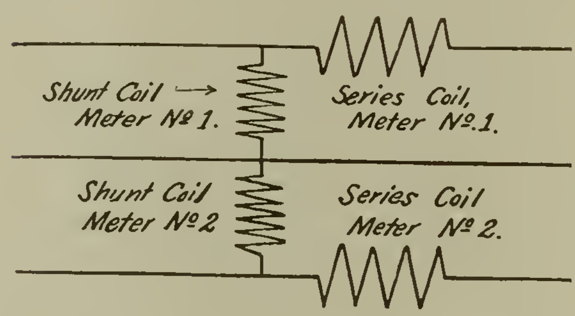


FIG. 1.

the top line downward. This oblique line intersects the curve at power factor .865 and the power factor is 86.5 per cent.

If wattmeter No. 2 reads a loss of 350 kilowatt-hours, then the ratio of the readings is indicated by the sixth line from the lowest oblique line and the power factor is .19 or 19 per cent.

Readings of *indicating* wattmeters may be utilized for finding the power factor at the time of taking the reading. With two indicating wattmeters connected as per Fig. 1, a reading of 700 k.w. on wattmeter No. 1 and 350 k.w. on wattmeter No. 2 indicates a power factor of 86.5 per cent. at the time of taking the reading. Readings must be taken at one time. It is important that the load be balanced or the results obtained will not be anywhere near accurate.

The chart is plotted accurately from calculation, as it is intended to be a labor-saving device. However, some will prefer to plot a curve with the ratio of wattmeter readings and the power factor as co-ordinates. This can readily be done. Readings of 700 and 350 give a ratio of one-half and power factor 86.5 per cent., similarly all the points may be plotted to include all power factors. A curve obtained in this way is simpler than the chart, but the ratio of the wattmeter readings must be calculated every time a power factor is to be obtained.

Some central stations are now equipped with graphic recording power-factor meters, which indicate the power factor at all times and record on a strip of profile paper the power factor accurately in per cent. Results can thus be compared with results secured at any previous time and defects or improvements noted.

The power factor of small feeders and that of any installation is measured with a portable power-factor meter of the size and general appearance of a voltmeter. Small series and voltage transformers are made for use with this meter, so that one set suffices for measuring any load at any voltage.

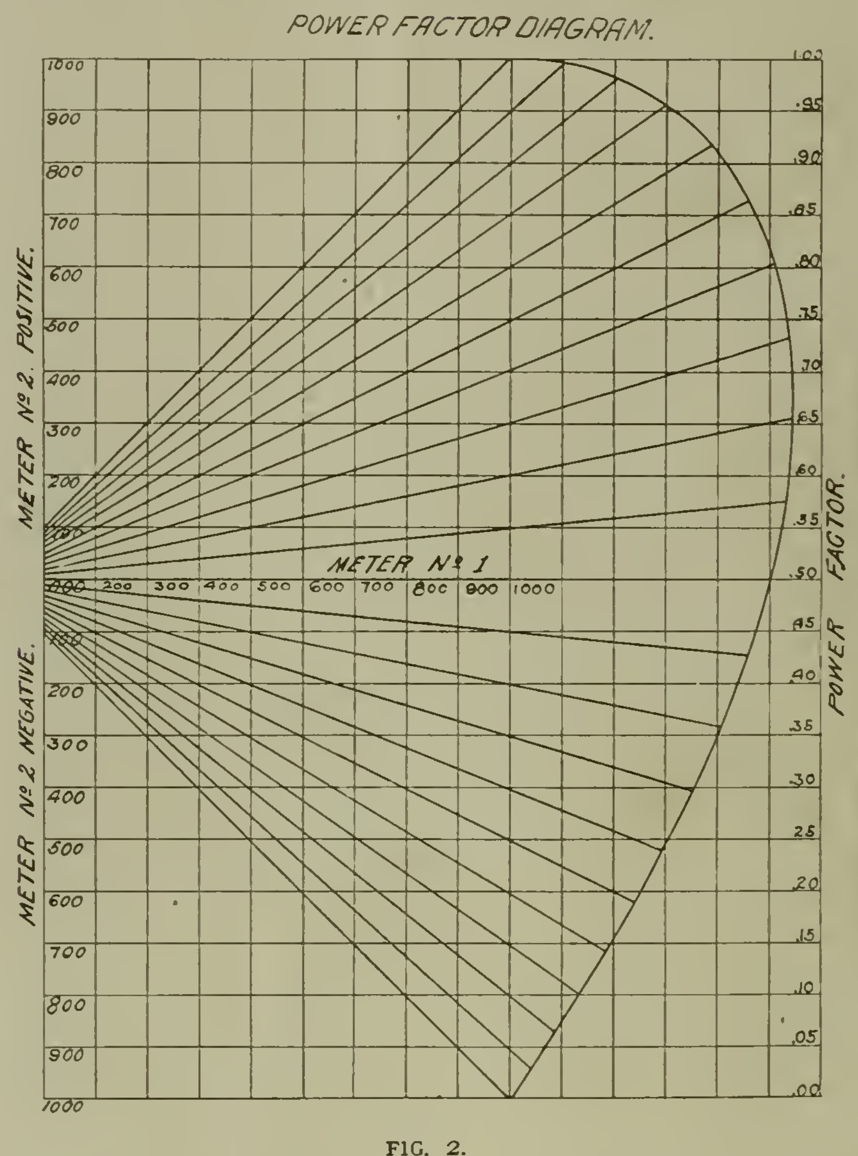
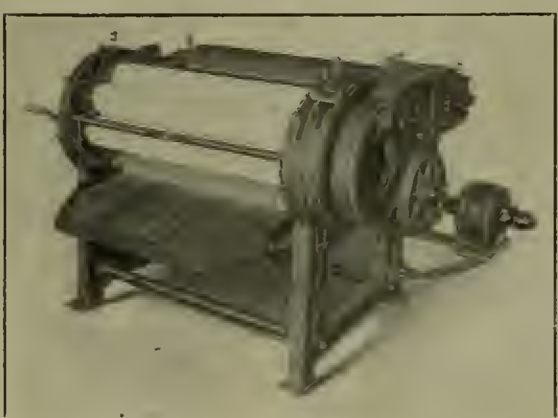


FIG. 2.

Electricity in the Laundry

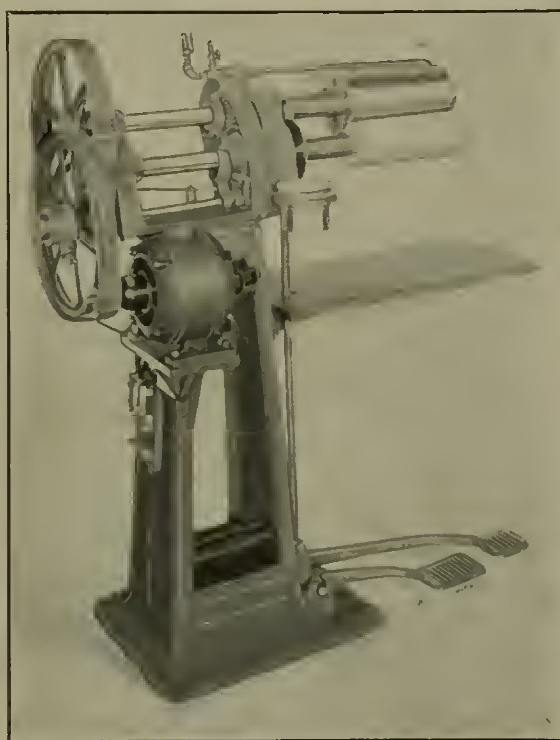
ONE of the fertile fields open to the introduction of electric power is what has been hitherto known as the steam laundry. In the past this line of work has been considered as lying almost entirely within the field to which steam alone was suitable, owing to the fact that high-pressure steam is required to supply the necessary amount of heat to the mangle rolls and ironers, etc. In those few cases where steam at from 80 to 100 pounds pressure was not available, gas-heated machines have been installed, and in a very few cases electrically heated machinery has been used. Electric irons for hand work are used in a number of places and give a much more satisfactory service than ordinary irons, owing to the fact that there is no time lost waiting for the irons to heat, and, in addition, the laundry stove is abolished.

The laundry field offers an excellent opening to exploit the use of direct-current motors, as it is necessary, owing to the character of the work, to install complicated and expensive mechanical transmission devices, in order to secure satisfactory results from alternating-current motors. Possibly the best solution of the difficulties in the way of using alternating-current for laundry work would be the installation of a rotary converter or motor generator set to supply direct current.



STEAM COLLAR AND CUFF IRONER. BARNES & ERB.

One of the advantages of the electric drives in the laundry lies in the fact that many of the operations are intermittent, and with the electric motors and heaters there is no consumption of power during the periods when the machines are not in operation. A further advantage, and no small one from the laundryman's point of view, arises from the fact that countershafts and belts are entirely done away with by installing a motor on each machine. With belts and shafting in use, it is almost impossible to avoid getting dirt and oil on work. The extent of this trouble will be appreciated when it is known that from 2 to 6 per cent. of the work has to be handled twice from this cause, and on occasions 20 per cent. of the work has had to be done over again. In one large laundry individual motors were installed solely to get rid of belts and shafting with their attendant dirt.



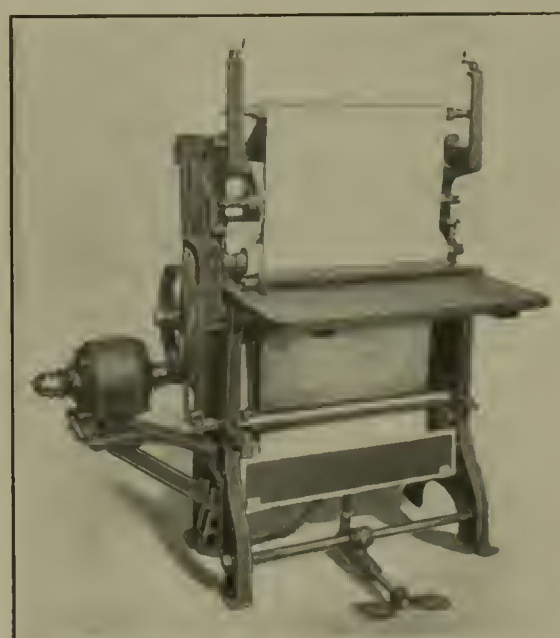
SLEEVE IRONER. STEAM HEATED ROLLS.

Owing to the foregoing reasons the subject of electric drives has become a very live topic among the laundry fraternity, and has occupied a prominent position on the program of all their recent conventions, one and in some cases two sessions being devoted to this subject. The laundryman is already interested.

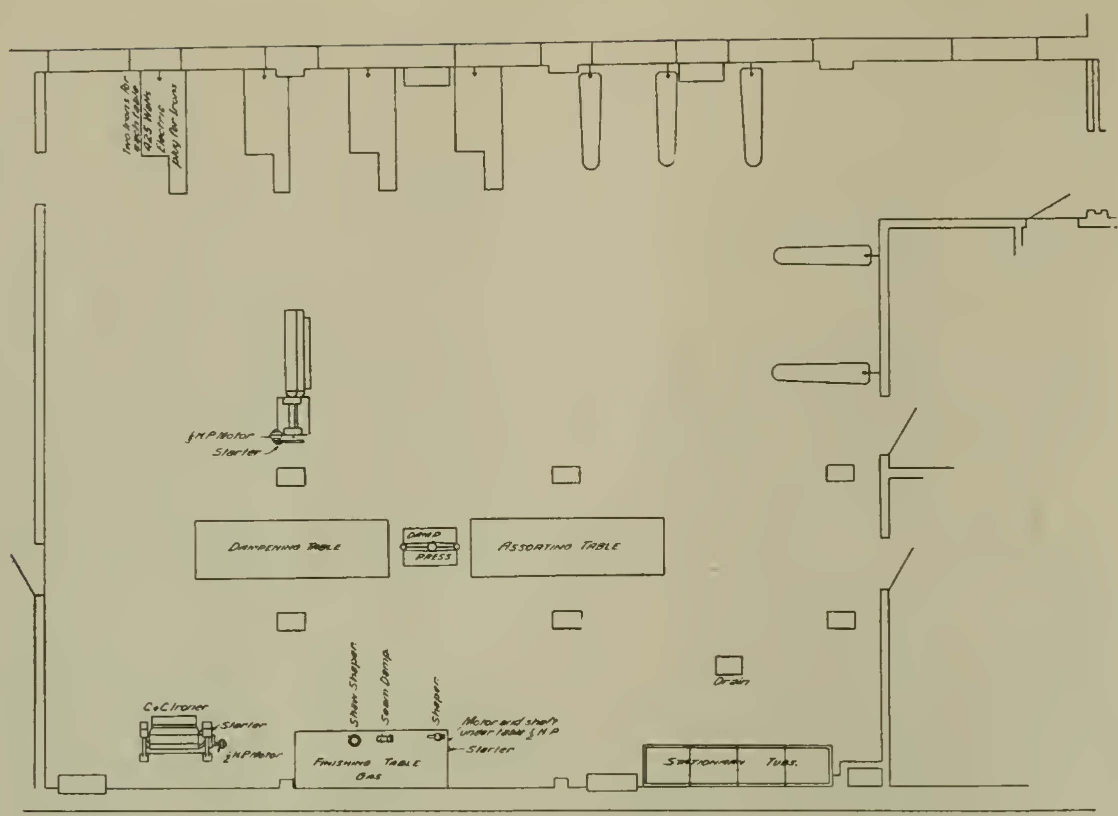
The laundry field, to a large degree, has been neglected, owing to the comparatively small size of the individual units. The trade has been heretofore somewhat difficult to cultivate, owing to its special requirements, which demand some knowledge of the conditions under which laundry machinery operates, and the fact that the proprietor does not appear to take much interest in load factors and other recognized methods of thinking for the electrical man, but utterly unknown to the laundryman. What the laundryman wants to know is how much it is going to cost to put in motors, approximately what it will cost to operate them, and some assurance about repair parts. He knows enough about machinery to know that it requires repair.

In laundry work the day's wash must be finished up that day, none of it being left over till to-morrow. Owing to this custom, the washing machines, which require the most power, are not in use in the latter portion of the afternoon. The washing in most cases is finished before two o'clock, and is an early morning load. The washing machines are occasionally driven by a reversible motor attached to each machine, but the usual equipment is to drive several washers from a line shaft with a reversing-belt drive to each machine; in this case from two to three horse-power is allowed for each machine. Slow-speed motors are required for direct drives, and they should be specially built to stand exposure to dense clouds of steam, and the enclosed type of motor is recommended.

The extractors are driven by series motors, and are used for only a few minutes at a time. These machines are built in several sizes and run at a high rate of speed. The load from these machines comes on just as soon as the first washer is emptied and they do not usually run later in the afternoon than three o'clock.



DAMPENER. BARNES & ERB. WATSON MOTOR.



BUNDLE WORK LAUNDRY.

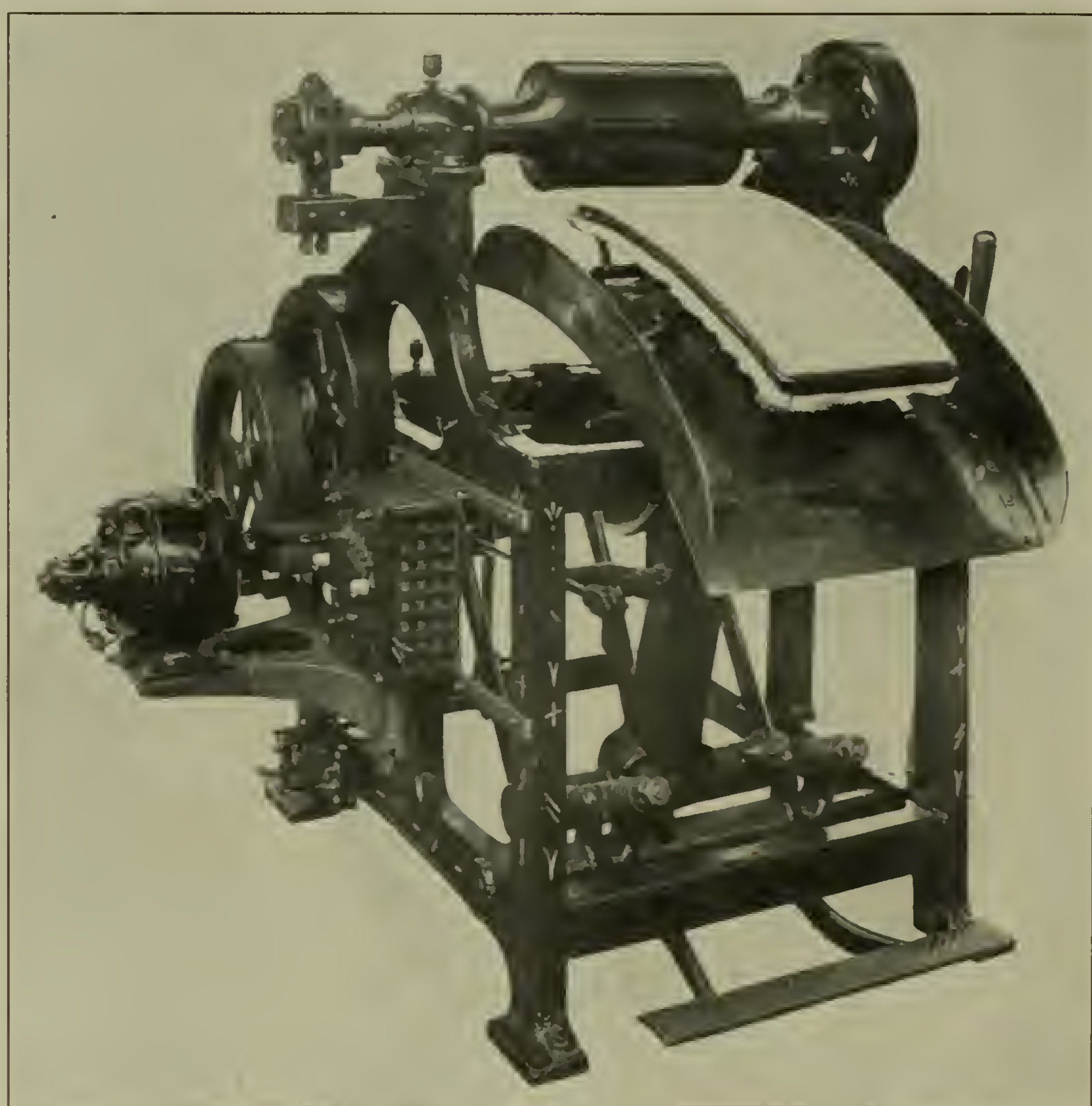
The accompanying line drawings illustrate two methods of connecting electric motors to extractors, in both of which belt drives are used to transmit the power. The quarter-turn arrangement is favored by the Crocker-Wheeler Electric Company, while Watson vertical motors are employed by the Mechanical Appliance Company. Some experimenting has also been done in the line of placing the armature directly on the basket spindle, which promises to make a very compact arrangement, the motor in this case being an integral part of the extractor. This latter method is, however, limited in its application to new machines.

Tumblers are installed in large laundries, to shake out goods which have become matted or tangled in the extractors, for which a reversible slow-speed motor of from one to two horse-power is required, according to the size of the tumbler. Washers and extractors never fall on the lighting peak.

The mangles, starchers, dry rooms, dampeners and ironers come into use just as soon as the work can be got to them. The mangles, which require a medium amount of power, usually come in service first and often run late to finish up the work. In large laundries there are usually several mangles adapted to different lines of work, while in the small laundry one mangle gets it all. In the larger sizes these machines are equipped with three to five speeds in the working direction and one reverse speed, in order to clear them from pieces which start crooked or stick in the machine. These speed variations and the reverse are usually obtained by the use of a special controller. In some cases mangles are equipped with electrically heated rolls instead of using steam for this purpose. The use of electrically heated rolls, in either mangles or ironers, is not common today, but it has many obvious advantages. There are no swivel steam and water joints to be kept tight, and the steam and drip pipes and the steam trap disappear. As the steam chests and rolls are not subjected to steam pressure they can be made lighter and the amount of radiating surface, as compared with useful heating surface, is reduced to a minimum. As a further advantage, an electrically heated machine does not require to be warmed up slowly and gets cool quicker than a steam-heated one, owing to the smaller mass of the heated portions; in addition, there is no waste of heat or power when the machine is not in operation. Mangles are used on flat work and are built in a number of different sizes to suit the work, which varies from handkerchiefs to sheets and curtains, etc.

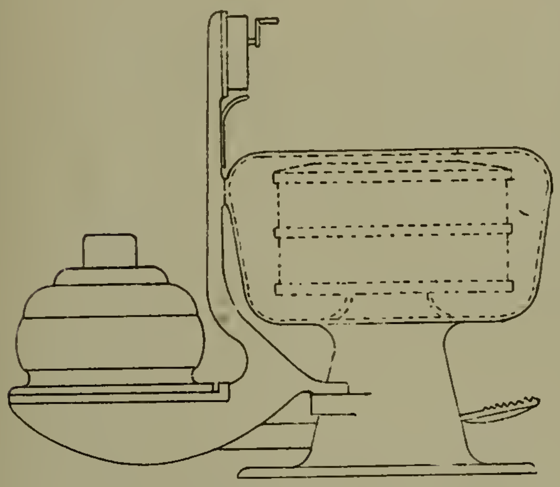
Starched work goes from the extractors or tumblers to the starching machines, which only require small motors of usually ¼-h.p. Some of these machines require a slow-speed reversible motor, while others always operate in the same direction. A good many of the small motors in laundry work are reversed by the use of a switch, which is thrown automatically, and are of necessity designed to meet this special requirement.

The next step is to the dry room, where much unstarched work and all



SHIRT BOSOM IRONER. ELECTRICALLY HEATED ROLL, WATKINS LAUNDRY MACHINERY CO.

of the starched work must be dried before ironing. There are two varieties of dry rooms, built in a variety of sizes. The conveyor dry room requires from one to two horse-power to operate it, and in those in which a fan is used to circulate the air, a ¼-h.p. motor is required to operate each fan; in this latter the work is hung on racks which are run in or out as required by hand.



EXTRACTOR WITH VERTICAL SHAFT MOTOR.

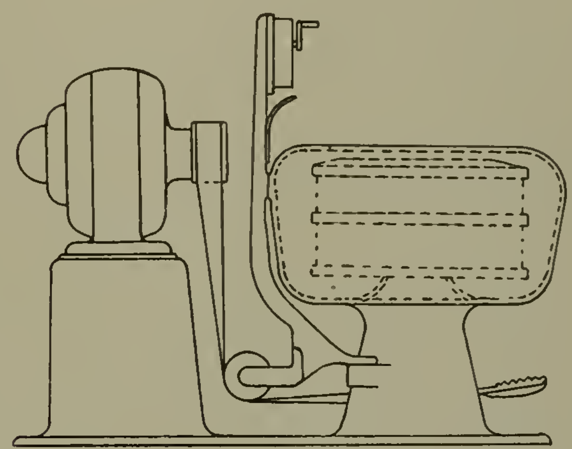
From the dry room the work goes to the dampeners and thence to the ironing machines, of which some require reversible motors, but none of them use more than ½ h.p. Domestic finish is obtained by pressing the work, in either a foot-power press, as for collars and cuffs, or in a hydraulic press for shirt bosoms. In the latter the pressure is limited to 550 pounds per square inch on the ram, the pump is operated by a ½-h.p. motor, and from 80 to 100 bosoms can be pressed per hour. A collar and cuff ironer can finish from 3000 to 4000 pieces per day.

In hand ironing, electric irons are rapidly displacing the old style, consuming from 230 to 610 watts per hour, according to size and weight. The most effective iron has two heating coils in each iron, one sufficient to keep the iron hot enough for use while it is on the stand, the other coming into action automatically as soon as the iron is raised from the stand and supplying the extra heat required while the iron is in use. This latter coil cuts out as soon as the iron is returned to the stand.

In regard to the cost of electricity as compared to steam operation of laundries, reliable data are difficult to get at, but electric operation appears to result in a considerable reduction of expense in other lines as well as the cost of operating, particularly in the case of large laundries. It has been claimed that the reduction in operating expenses was as much as 30 per cent. in some cases, and in other small plants less than 5 per cent. In the latter case it was considered that the added convenience had more than made up for the expense of the electric equipment.

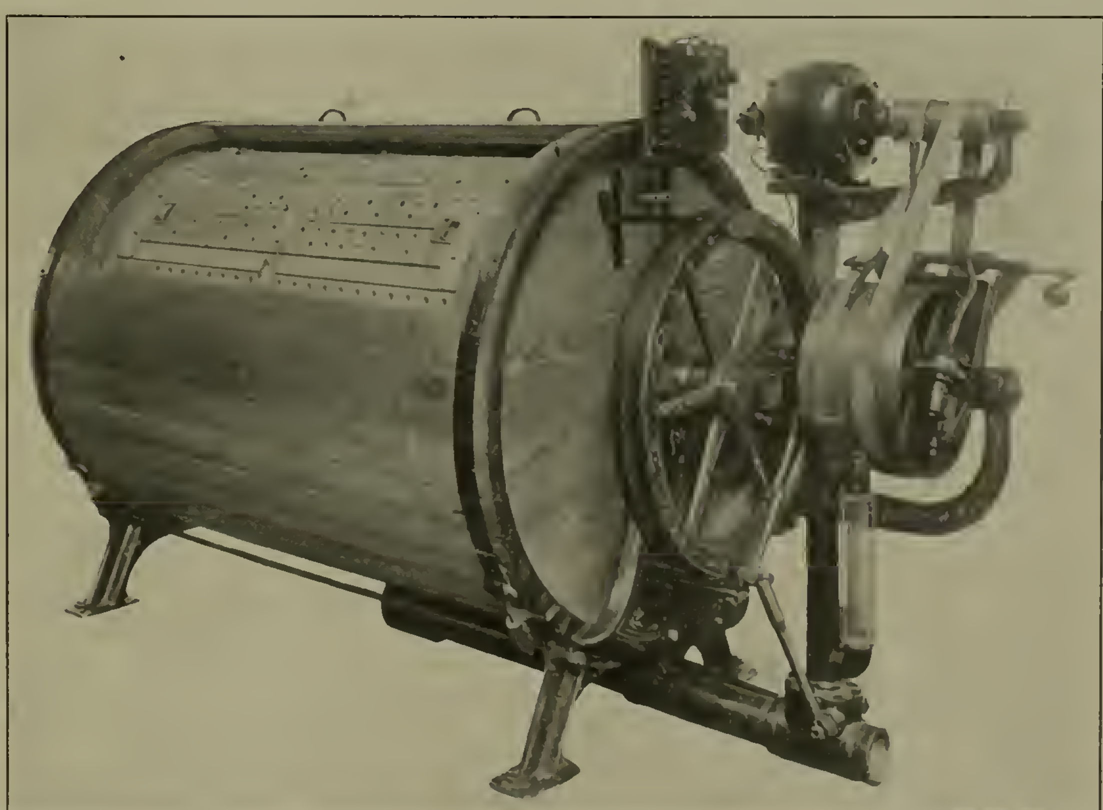
One of the possibilities of the electric drive is the opportunities it offers to increase the output of the individual machines by a little intelligent experimenting. The increase in output obtainable varies. In one case it was 300 per cent., due to well-directed study of the conditions of the plant, though increases of from 50 to 100 per cent. are not unusual. As an illustration of how this is done, in a laundry extractor running at 1000 revolutions, it was found that the basket was of ample strength to permit the speed to be increased to 1400 revolutions, and a little experimenting demonstrated that at speeds between 1250 and 1400 revolution the work came from the extractor with just the right degree of dampness for the next process, and the time required to dry the work was reduced to six minutes. The speed of the extractor, however, should not be altered on any guess-work basis. A number of these machines, when they were first built, went to pieces with serious results, as the peripheral speed is from 5000 to 7000 feet per minute.

In most of the large modern laundries electric drives are used in order to avoid the use of belts and shafting, with their attendent dirt. The trouble from this cause has often been the final argument to induce a laundry to use the electric drive. In one case $10,000 was required to make the change, and it was found possible to greatly increase the output from the various machines by adjusting their speeds accurately to suit the work, a thing practically impossible with belt drives. It was also found that the saving in cost of turning out the work saved enough to warrant the purchase of additional machines. This laundry was able to turn out more and better work at a lower cost, and naturally increased its business. Another argument against belts and shafting is the number of accidents caused by their use, particularly to the women employees. The motor drive greatly reduces the danger of accidents to help. One of the features to be noticed in the accompanying illustrations is the complete manner in which the various gear wheels are enclosed and guarded.

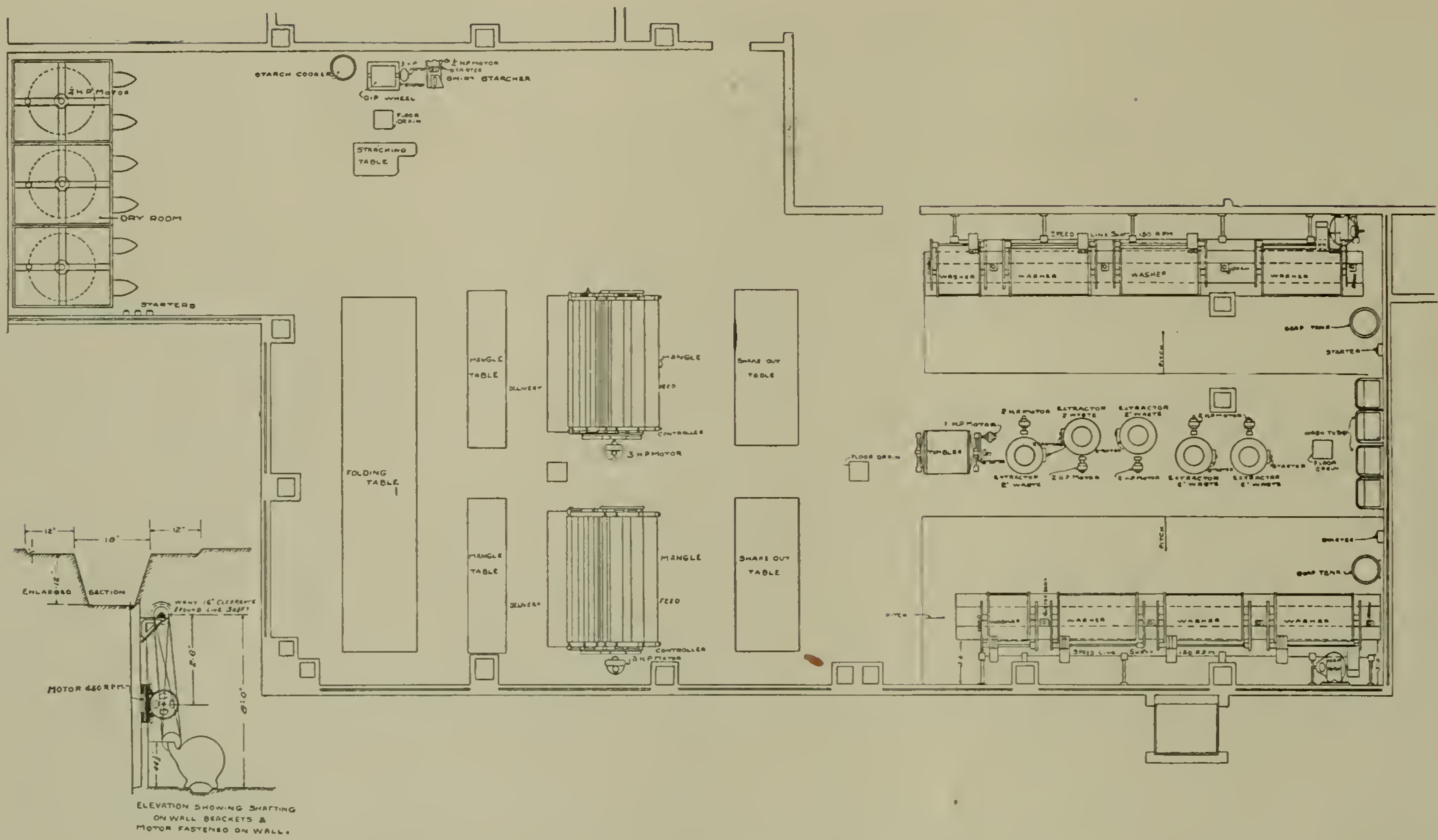


EXTRACTOR WITH HORIZONTAL SHAFT MOTOR.

With regard to the cost of installing electric motor drives, conditions vary greatly, and it is almost impracticable to give a general rule. The following, however, is based on experience gained in the equipment of a number of laundries of different sizes, and is therefore a fair average. Note the amount of power required to operate



WASHING MACHINE. REVERSIBLE BELT DRIVE.
WATKINS LAUNDRY MACHINERY CO.



MOTOR-DRIVEN LAUNDRY EQUIPPED TO HANDLE A LARGE AMOUNT OF FLAT WORK.

each machine, the sum of these figures will be the total horse-power of motors required; multiply this sum by 150 and the product will be approximately the cost in dollars of installing an individual electric drive. The second-hand value of old belts and shafting is so small that it hardly pays for their removal. The shafting is hardly in demand at ⅛ cent a pound.

The following tables give a list of the different sizes of laundry machines and the power of the motor required to drive them, and the current consumed by electric irons. This data has been gathered from a number of sources and can be relied upon. Owing to the large number of sizes listed for washing machines, no attempt has been made to specify the size of the individual motor required.

POWER CONSUMPTION OF ELECTRIC IRONS.

	WATTS MIN.	WATTS MAX.
Sleeve irons	230	300
Polishing irons, 4½ lbs.	255	330
Polishing irons, 6½ lbs.	275	450
Smoothing irons, 6½ lbs.	275	450
Smoothing irons, 8½ lbs.	325	540
Smoothing irons, 10 lbs.	375	610

KIND OF MACHINE AND NUMBER	SIZE OF MOTOR H. P.
Body ironer	¼
Body ironer reversing	½
Band ironer	⅛
Band starcher	⅛
Bosom ironers	¼ reversible
Bosom press	½
Collar and cuff dampener	¼
Collar and cuff starcher	¼
Collar and cuff ironer 22 in. roll	½
Collar and cuff ironer 28 in. roll	1
Collar and cuff shaper tables	¼
Combination ironers	¼
Dry rooms, conveyor	1 to 2

KIND OF MACHINE AND NUMBER	SIZE OF MOTOR H. P.
Dry rooms, for each fan	½
Extractor, 20 in. basket	1 series
Extractor, 24 and 26 in. basket	1½ series
Extractor, 30 basket	3 series
Extractor, 32 basket	4 series
Mangles, handkerchief all sizes	½ Variable speed controller with reverse
Mangles, 108 in. single roll	1 "
Mangles, 104 in. two rolls	1 "
Mangles, 120 in. three roll	1½ "
Mangles, 100 in. five roll	1½ "
Mangles, 120 in. five roll	3 "
Mangles, 120 in. six roll	3 "
Mangles, 120 in. eight roll	3 "
Reversing sleeve ironer	⅓
Shirt dampener	⅓
Shirt and bosom starchers	½ reversible
Sleeve ironers roller and swivel	¼
Clothes tumblers, 36 by 48	1 reversible
Clothes tumblers, 48 by 54	2 "

Electric Motor Connections

Shunt Wound Motors

NORMAN G. MEADE

OUTSIDE of railway work, the shunt motor is more largely used than any other type owing to the valuable speed-regulating qualities which adapted it to the operation of nearly all kinds of machinery. With this type of motor, the current flowing through the field coils is constant, as long as a constant electromotive force is maintained on the line. The field coils will, therefore, supply the same magnetizing force, no matter what current the armature may be taking from the mains. The strength of the fields would be practically constant if there was no demagnetizing action of the armature. Take the case where the motor is running free and the only load which the armature currents have to overcome is the friction and the losses within the armature. The amount of energy which the motor will take from the line will just be sufficient to counterbalance these losses, and the armature will run up to a speed at which the counter electromotive force will allow just sufficient current to flow to supply the loss of energy. Since this current is very small in a good motor, the counter electromotive force when the motor is running light is very nearly equal to the impressed or line electromotive force.

When load is applied the motor must take sufficient current to enable the armature to produce a torque sufficient to carry the load. In order to allow this current to flow, the counter electromotive force must drop slightly, and as the speed is nearly constant, this means a slight lowering of speed. At the same time it must be remembered that the armature reaction is greater when the motor is loaded than when it is not loaded, and the weakening of the field by this reaction tends to keep the speed up. The net result is, therefore, that a shunt motor operated on a constant potential circuit falls off slightly in speed as the load is applied, but if the motor is well designed and has a low-resistance armature, the falling off in speed from minimum to maximum load will be very small. It is this speed-regulating feature which results in the shunt motor being so widely used. If the load should be accidentally thrown off, there is no tendency to race and the motor automatically adjusts itself to changes in load without materially changing its speed and without the aid of any mechanical regulating devices.

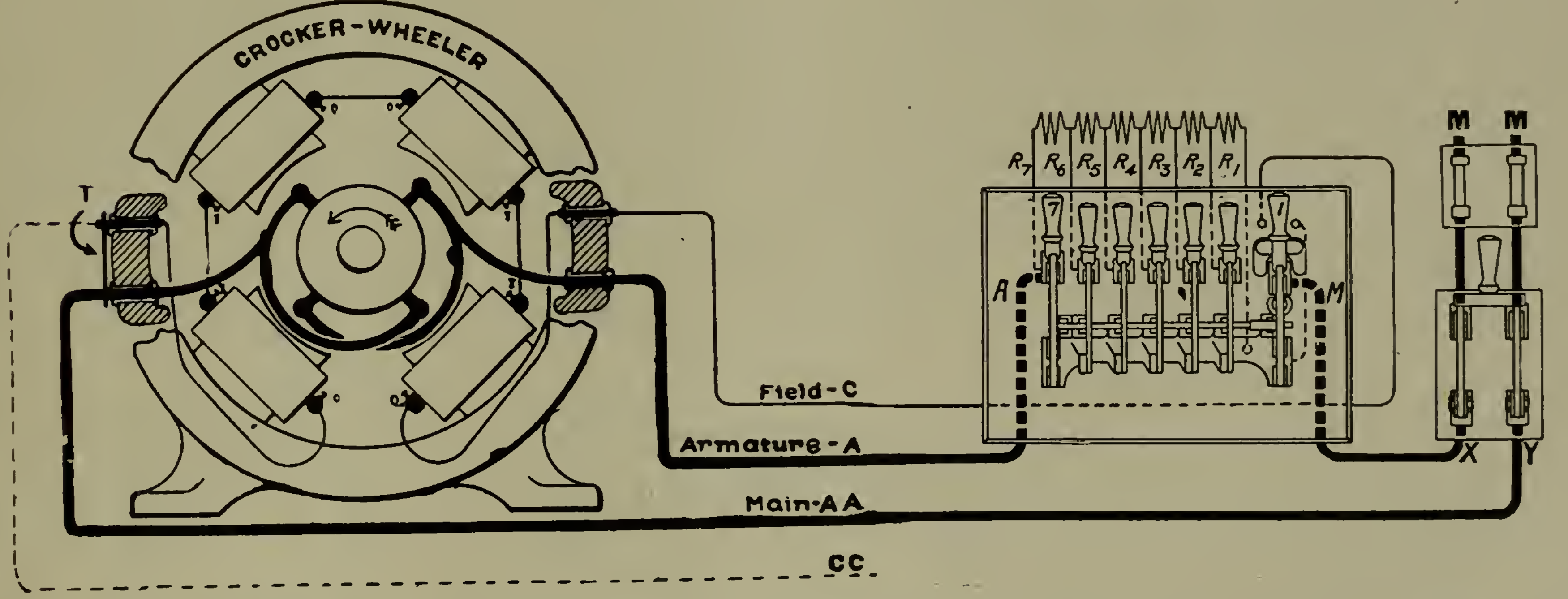


FIG. 28.—SHUNT WOUND MOTORS, FORM F AND I. SIZES 3, 5, 7½, CROCKER-WHEELER COMPANY, BLADE STARTER WITH AUTOMATIC CUT-OFF. (MAGNETS IN SERIES WITH FIELD.)

To change direction of rotation, connect armature cables to bottom brushes, as shown in Fig. 29.

FIG. 29

If motor must run in both directions, remove copper connector "T" and use dotted connection also. Set rocker so that motor runs equally well in either direction.

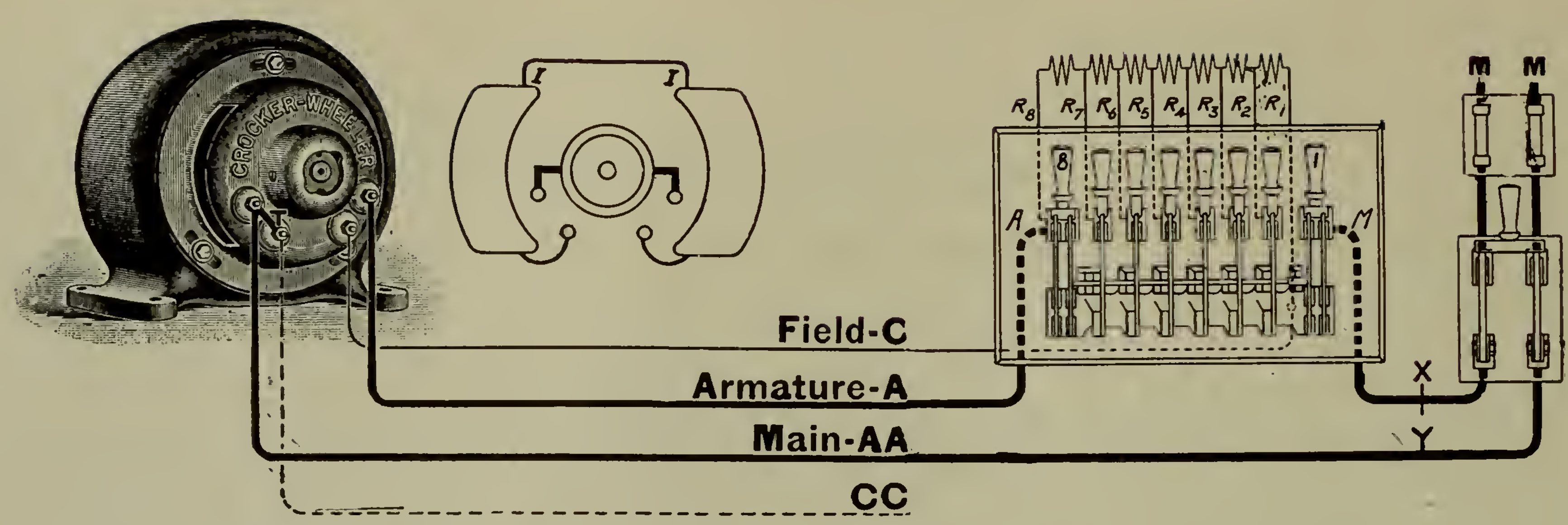


FIG. 30.—SHUNT MOTORS, FORM L. SIZES ¼ TO 2. CROCKER-WHEELER COMPANY. WITH BLADE STARTER.

Connector "T" must be removed when motor is connected up by the four wires as shown.

To reverse the direction of rotation, remove copper connector "T" and put in a connector between the Terminals "AA" and "C," then use the]dotted connection "CC instead of "Field-C".

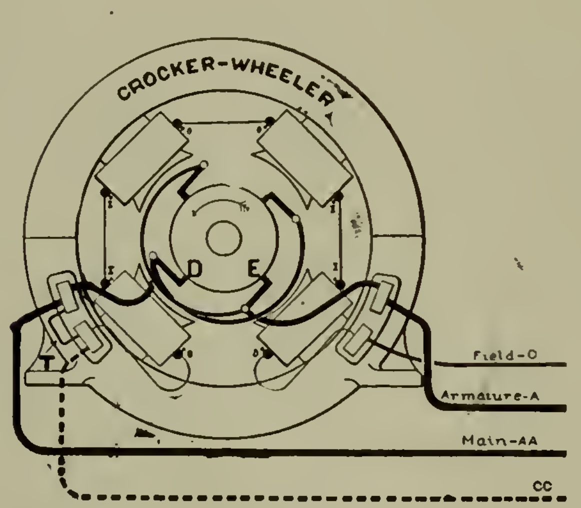


FIG. 31.—SHUNT MOTOR, FORM D, SIZES 51 AND 76. CROCKER-WHEELER COMPANY.

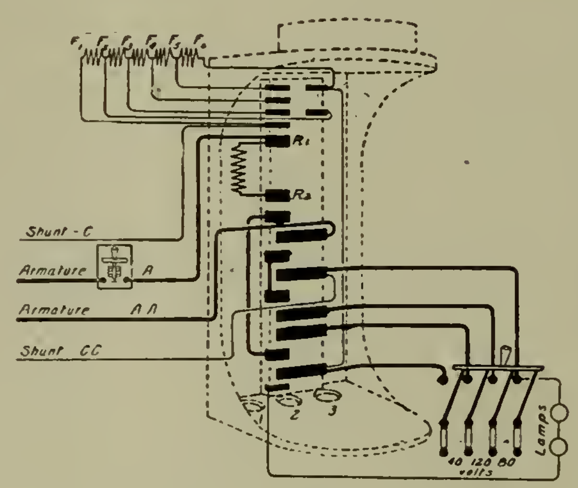


FIG. 32.—WIRE DIAGRAM, SIZE 40, 80 OR 150 M. F. CONTROLLER WITH SHUNT MOTOR FOR MULTIPLE VOLTAGE SYSTEM. CROCKER-WHEELER COMPANY.

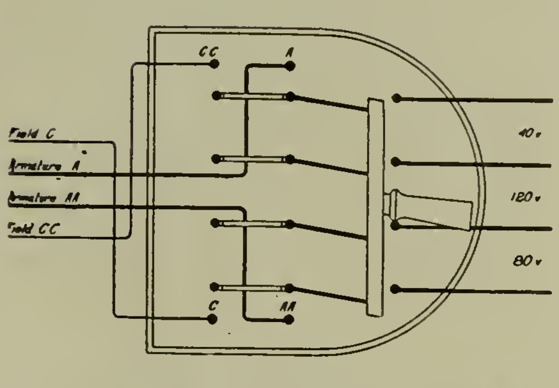


FIG. 33.—WIRING DIAGRAM, SIZE 30, M. F. II CONTROLLER WITH SHUNT MOTOR FOR MULTIPLE VOLTAGE SYSTEM. CROCKER-WHEELER COMPANY.

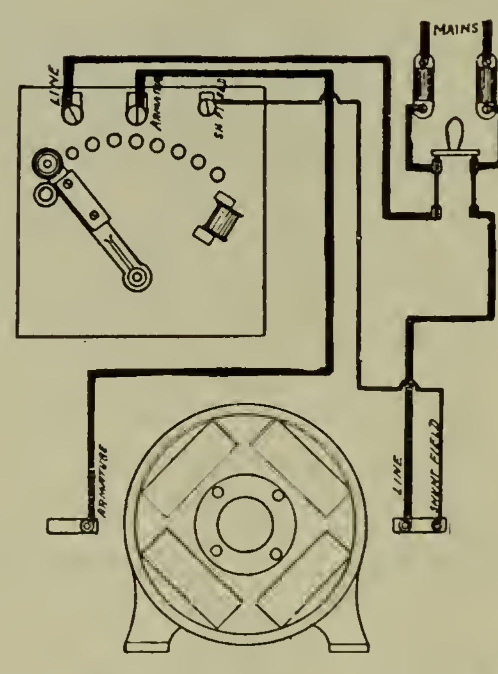


FIG. 34.—CONNECTIONS FOR AUTOMATIC RHEOSTAT AND TYPE "S-L" MOTOR. THE C. & C. ELECTRIC COMPANY.

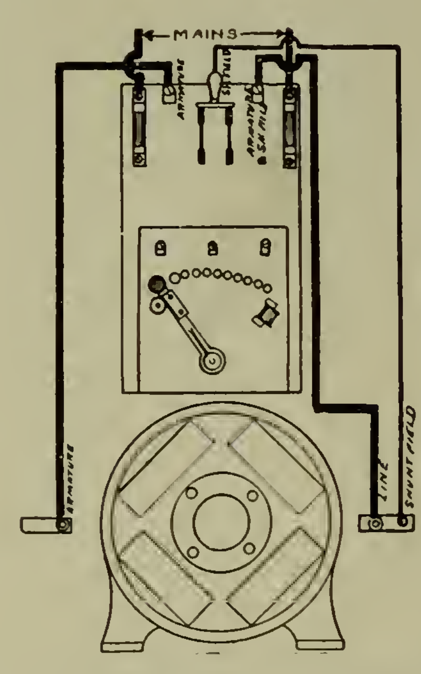


FIG. 35.—CONNECTIONS FOR UNIVERSAL RHEOSTAT AND TYPE "S-L" MOTOR. THE C. & C. ELECTRIC COMPANY.

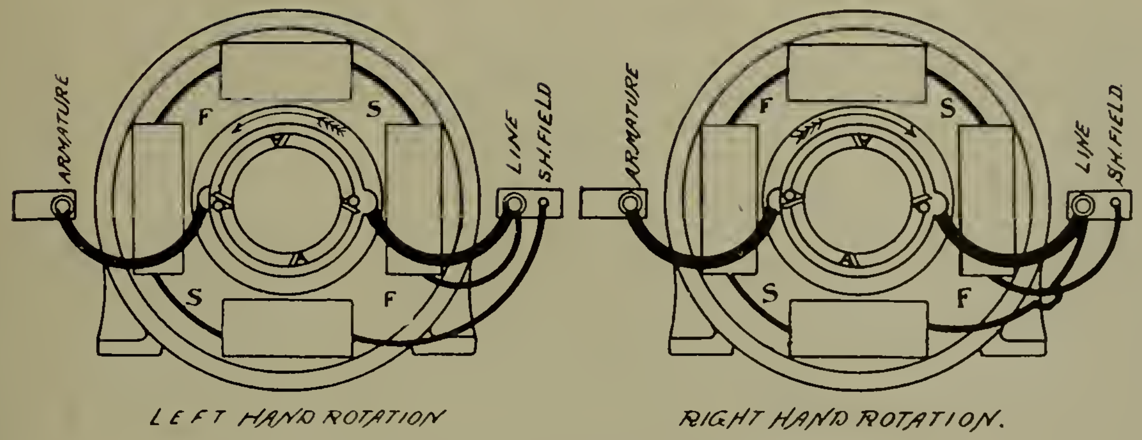


FIG. 36.—CONNECTIONS FOR MP. 4 SHUNT MOTORS.
THE C. & C. ELECTRIC COMPANY.

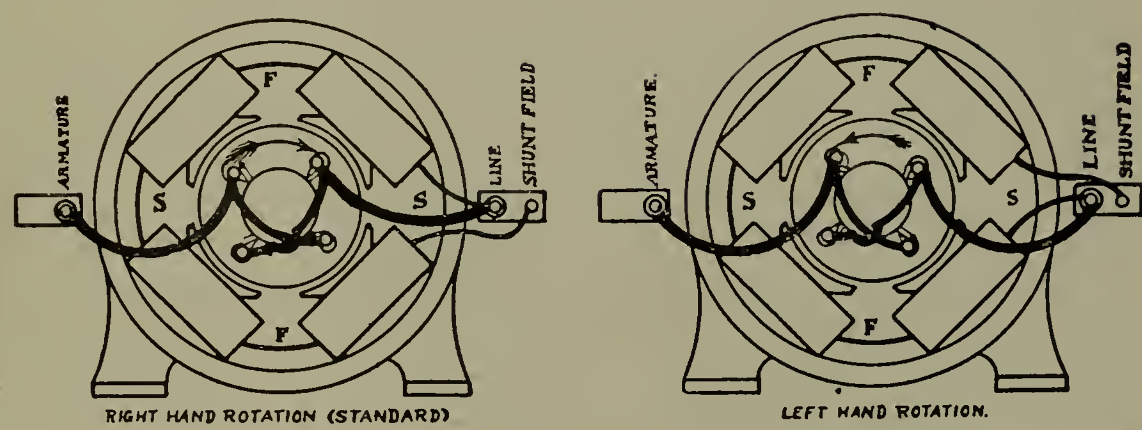


FIG. 37.—STANDARD CONNECTIONS FOR TYPE "S-L" SHUNT MOTORS.
THE C. & C. ELECTRIC COMPANY.

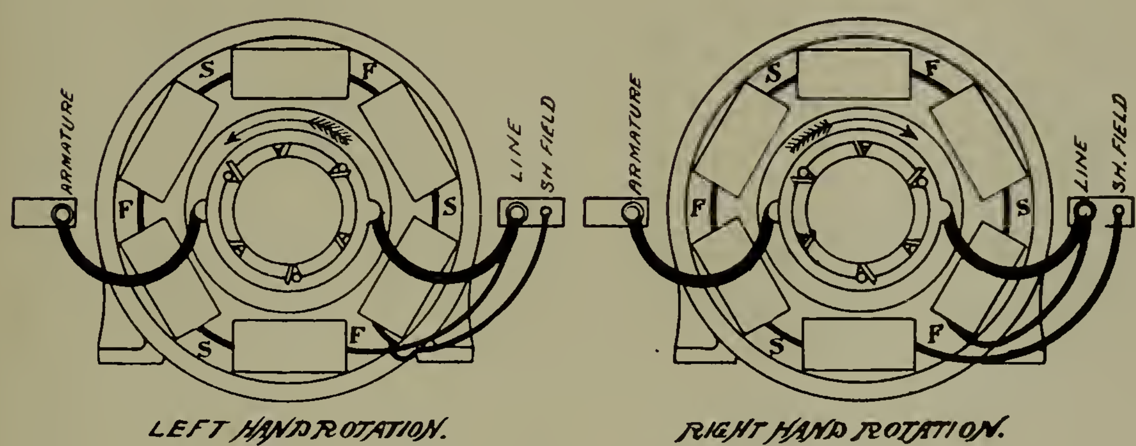


FIG. 38.—CONNECTIONS FOR MP. 6 SHUNT MOTORS.
THE C. & C. ELECTRIC COMPANY.

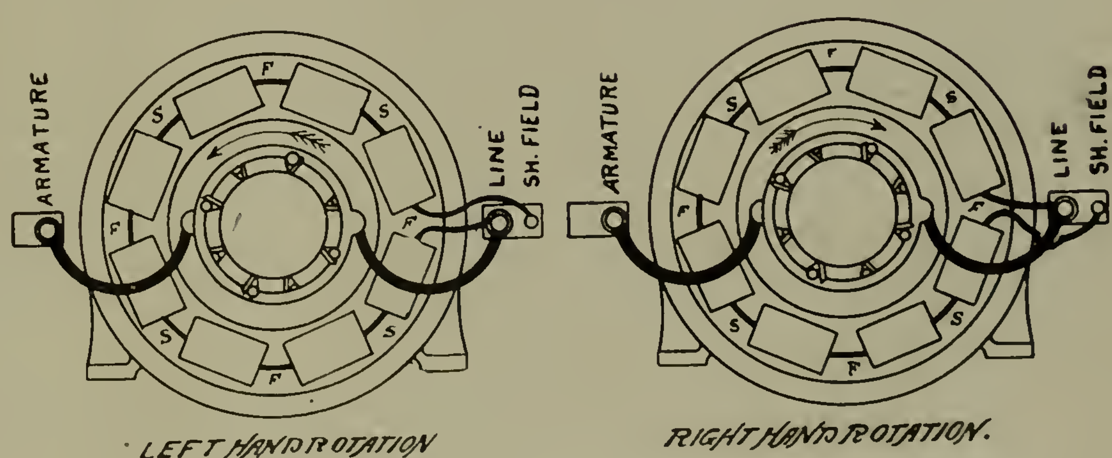


FIG. 39.—CONNECTIONS FOR MP. 8 SHUNT MOTORS.
THE C. & C. ELECTRIC COMPANY.

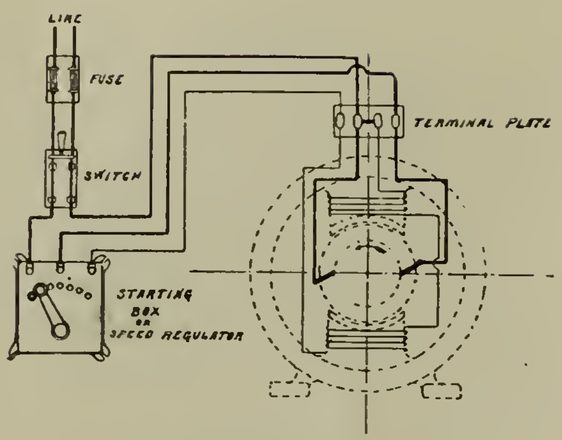


FIG. 40.—WIRING DIAGRAM TYPE "D" MOTOR 2 POLE.

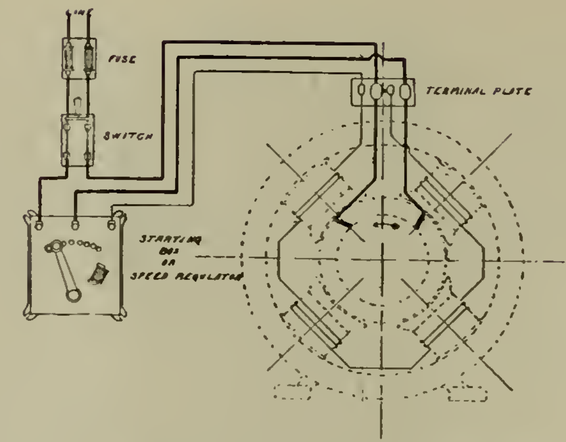


FIG. 41.—WIRING DIAGRAM TYPE "E" MOTOR WITH 2 BRUSH STUDS.

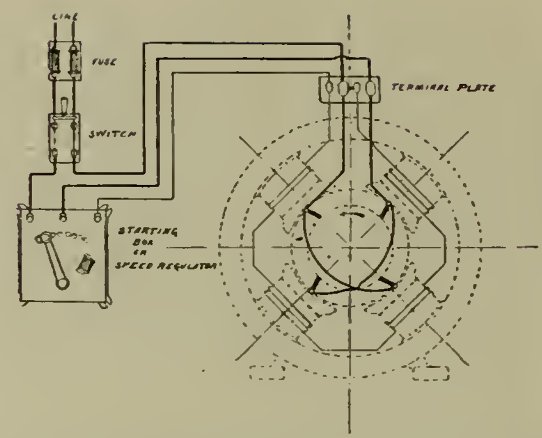


FIG. 42.—WIRING DIAGRAM TYPE "E" MOTOR WITH 4 BRUSH STUDS.

SHUNT WOUND MOTORS, DIEHL MANUFACTURING COMPANY.

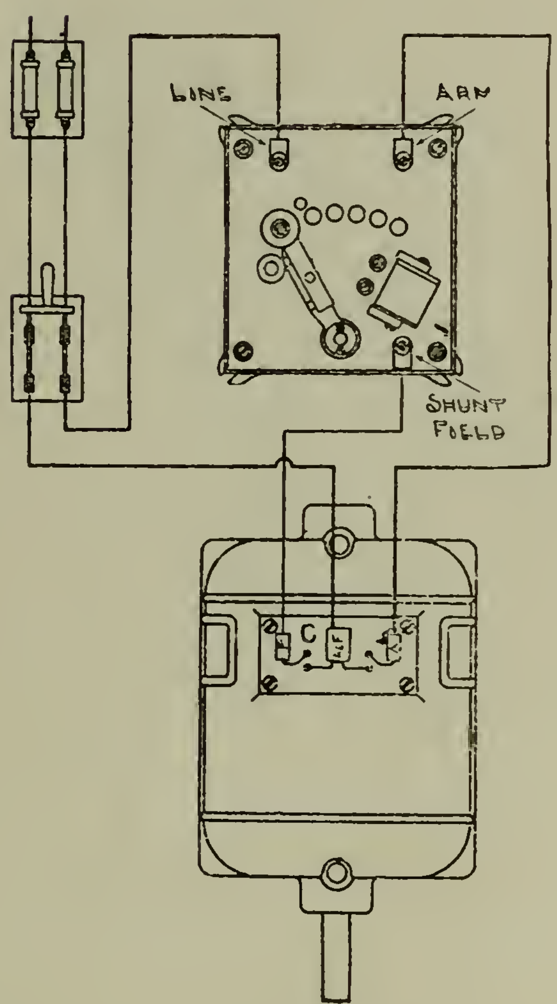


FIG. 43.—SHUNT WOUND MOTOR. THE EMERSON MANUFACTURING COMPANY.

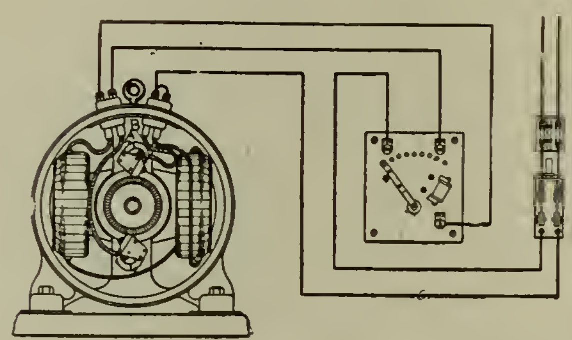


FIG. 44.—BIPOLAR SHUNT WOUND MOTOR. ALLIS-CHALMERS COMPANY.

Right hand rotation. For left hand rotation, reverse brushes and interchange leads "A" and "B."

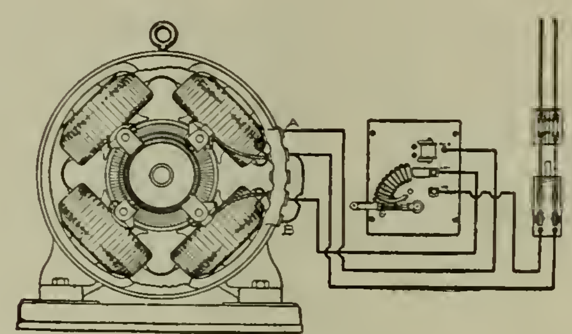


FIG. 45.—FOUR POLE SHUNT WOUND MOTOR. ALLIS-CHALMERS COMPANY.

Right hand rotation. For left hand rotation, reverse brushes and interchange leads "A" and "B."

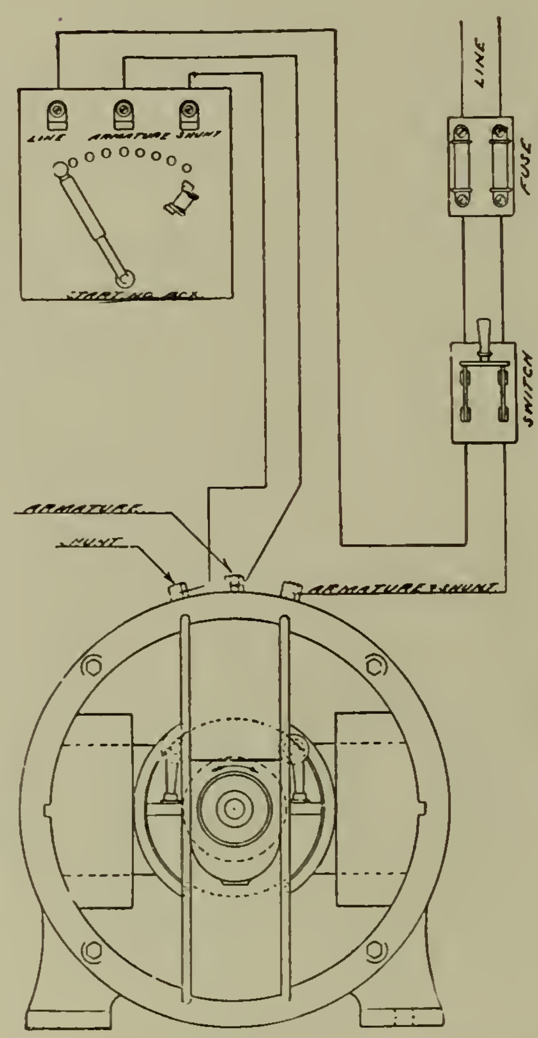


FIG. 46.—DIAGRAM OF CONNECTIONS STEEL FRAME BIPOLAR SHUNT WOUND MOTOR, WITH CUTTER-HAMMER AUTOMATIC RELEASE. TRIUMPH ELECTRIC COMPANY.

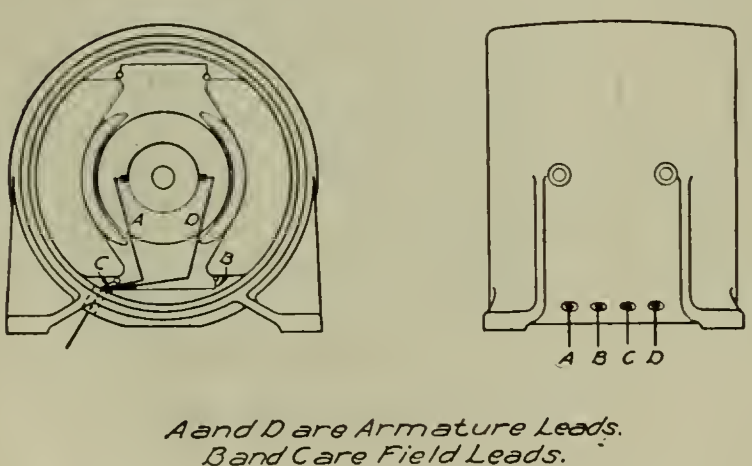


FIG. 47.—SHUNT WOUND, C. R., BIPOLAR MOTOR. GENERAL ELECTRIC COMPANY.

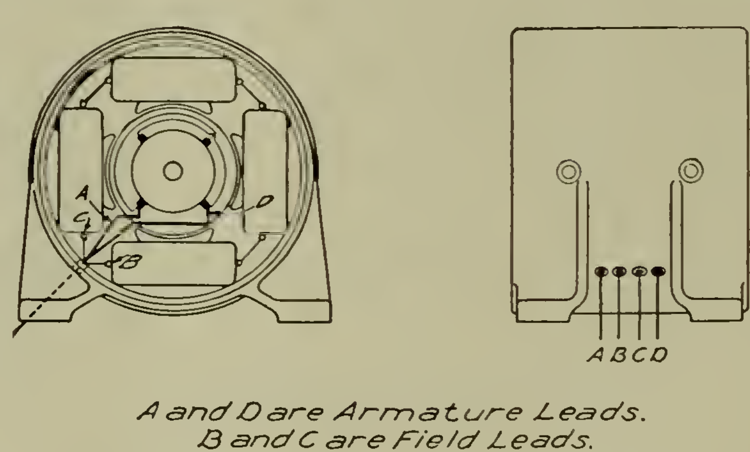
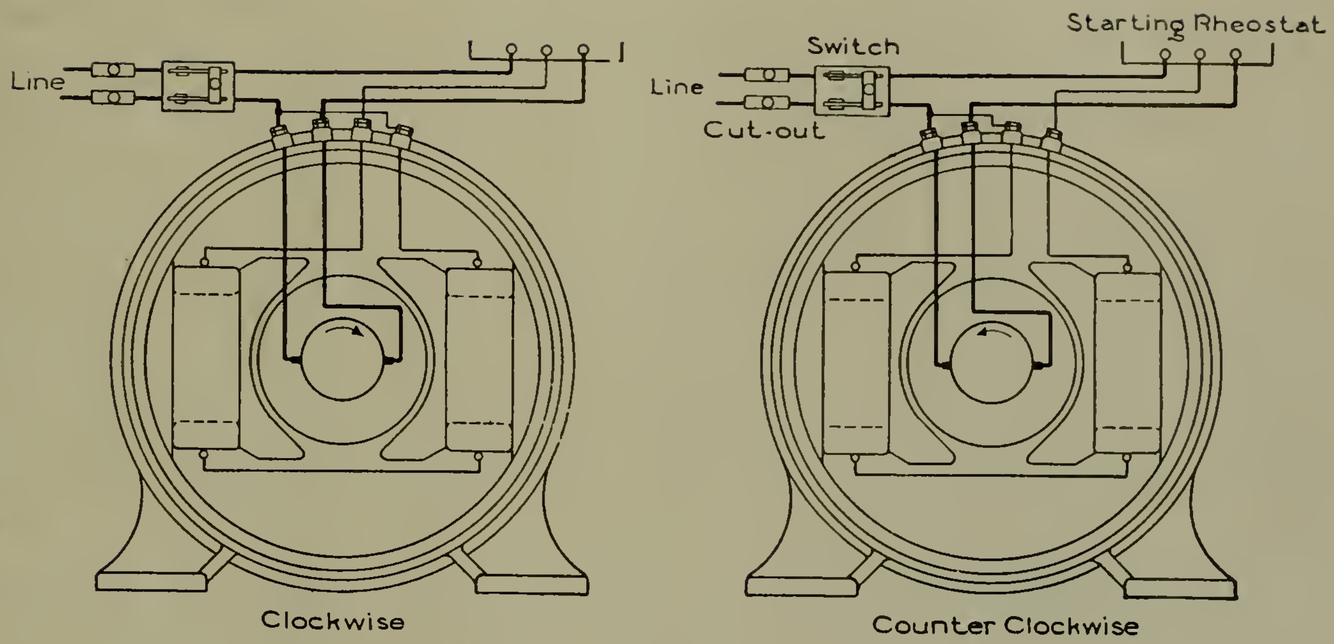


FIG. 48.—SHUNT WOUND, C. R., FOUR POLE MOTOR. GENERAL ELECTRIC COMPANY.



An arrow and the letter "I" or "O" are cast on each of the Terminals of the field coils. The coils should be so assembled on the poles that the arrow will point toward the Armature and the like letters will be adjacent for connection together.

FIG. 49.—SHUNT WOUND, C. E. MOTOR, FOUR POLES. GENERAL ELECTRIC COMPANY.

(Shunt Motor Connections will be continued in the next issue.)

Getting New Business

BY getting up and going after new business the Janesville Electric Company, of Janesville, Wis., has largely increased the number of users of electric light and power, having within the last year added to its circuits 125 horse-power of motors, 2372 lamps of various sizes and 150 electrically heated flat-irons. The receipts from incandescent lighting were 25 per cent. higher for March, 1907, than they were in this same month of 1906. This result was reached not by waiting for new business to walk in, but by going out after it, personally and through advertisements. Present customers are not neglected, and a well-directed campaign is kept up to educate them in the more varied uses of electricity.

A list of prospective customers is kept, and to them and a number of the present customers a booklet is mailed from time to time, 1000 being sent out each month. These booklets have been found of use in creating a friendly sentiment toward the company, in addition to their educational results.

Two solicitors are employed, who draw a salary and receive a percentage on the first year's receipts of the new business they bring in. These men also read the meters and collect the bills and in this manner keep closely in touch with customers, and have an opportunity to locate prospective customers on their routes and to report all new building operations and alterations. As a result of this method nearly all of the new buildings put up are wired before completion, and a number of older buildings have been wired while other alterations were in progress. Necessarily, these results were not secured in a day, but are the results of several years work in co-operation with architects, builders, etc.

Outside lights, electric signs and show windows are contracted for at a flat rate the year round, to burn from dusk to 11 P. M. These lights are turned off by a watchman and the customer does not have to bother with them. In introducing electric signs a list of prospective users of these devices was sent to some of the large sign makers, who sent out their advertising matter and follow up letters, in addition to the work of the solicitors of the company. This campaign

MONEY SPENT FOR

ELECTRIC LIGHT

is not expense; it is advertising, and good, profitable advertising at that. A well-lighted store not only invites customers but shows a confidence in your goods. Electrically lighted show windows attract attention when people have leisure for inspecting them and will often make a sale the night before for you.

JANESVILLE ELECTRIC CO.

Both Phones On the Bridge

IMPORTANT!

The substitution of tantalum for carbon in the manufacture of electric light globes has increased their efficiency 30 per cent. You can get one-half more light for the same amount of current by using the Tantalum Lamp in place of the ordinary one. Drop in our office and see a practical demonstration of this fact.

Janesville Electric Co.

ADVERTISEMENTS USED IN LOCAL PAPER.

JANESVILLE ELECTRIC CO.

JANESVILLE, WIS.

NOTICE TO CONSUMERS

We desire to render satisfactory service and merit the confidence and friendship of our customers; therefore, will deem it a favor if we are promptly advised of any cause of dissatisfaction.

Bills may be reduced and controversy avoided by promptly extinguishing lamps when not in use. In case of dispute the bill should be paid in time to obtain the cash discount, leaving rebates or corrections to be adjusted later.

The company should be notified in case of removal ordiscontinuance of service, as the minimum rate is charged until such notice is given.

Bills rendered at time of removal or vacation of premises, or to discontinuing customers, and special bills are payable on presentation.

Lamps burned out of 10, 16, 20, 24 and 32 C. P. "regular plain," will be renewed free to customers, upon the return of the glass bulbs, unbroken, to the office of the company.

Lamps accidentally broken, lost, or unaccounted for by customers, will be charged to them at 20 cents for 10, 16, 20 and 24 C. P., and 30 cents for 32 C. P. lamps.

Lamps other than "regular plain" will be charged for extra, at the following rates:

Frosted,	(to subdue the intensity of the light)	5c. each
Superficially dipped,	—red, blue, green, purple or amber	5c. "
Naturally colored glass,	—blue, green or purple (16 C. P. only)	12c. "
" " "	—ruby or opal (16 C. P. only)	20c. "

Our employes shall, at all reasonable hours, have free access into customers' premises to inspect the meters, lamps and wiring, or to remove the company's property.

The company does not guarantee an absolutely uninterrupted service, and it will not be liable for damages, for stoppage of lights, but a proportionate deduction will be made from the rent for such stoppage.

RATES AND DISCOUNTS

Current for Incandescent Lamps, low tension Arc Lamps, etc., ten cents per 1,000 watt. hrs.
Current for Electric Motor Power, five cents per 1,000 watt. hrs.
Above rates subject to discounts for quantity consumed as follows:

Bills of from $ 5 to $10 per month, 5 per cent. discount.
Bills of from $10 to $20 per month, 10 per cent. discount.
Bills of from $20 to $30 per month, 15 per cent. disocunt.
Bills of from $30 to $40 per month, 20 per cent. discount.
Bills of from $40 to $50 per month, 25 per cent. discount.'
Bills of from $50 and over per mo., 30 per cent. discount.

When current consumed for Incandescent Lamps in any month is less than 10,000 watts hours, a minimum charge of $1.00 for the month shall be paid to cover the expense of inspecting and maintaining meters and service connections, in addition to the following minimum rates:

For each Motor of 1-H. P. and less (nominal rated capacity), a minimum charge of $1.25 per month shall be paid; and for each Motor of over 2-H. P. a minimum charge of $1.00 per month shall be paid for each H. P or fraction thereof, of the nominal rated capacity of the Motor.

Where lamps burn long hours we give a special rate when a contract for one year is made. These rates may be had on application at the office.

Show windows, signs and outside lights may be contracted for at a flat rate the year round, the lights to burn every night from dusk until 11 p. m. We will turn them on and off.

Five per cent. cash discount allowed from all of above rates if bill is paid within **twelve days.**

ANNOUNCEMENT ON BACK OF BILLS.

Use Electric Light . .

Stop scratching the matches on the wall. It spoils the wall paper. But as long as you use gas or oil you've got to use matches. The "matchless light" is Electricity—a touch of the button does it.

Janesville Electric Co.

A WASHER AND WRINGER

Operated by a small electric motor is on display at our office. It saves lots of time and labor, costs but two cents an hour to run.

Drop in and see it.

Janesville Electric Co.

ADVERTISEMENTS USED IN LOCAL PAPERS.

resulted in placing 48 signs in use, which helps to make the streets of Janesville look pretty lively, for those of a city of 13,000 inhabitants.

One of the lines which the company has gone into extensively is the sale of power, every line of business being canvassed as a prospective motor-using possibility. The grocer has been induced to grind his coffee by power, and the butcher uses a motor to run his meat chopper. The blacksmith has a motor direct connected to the forge blower and uses a motor-driven emery grinder instead of a file. In addition the grain elevators, shoe factories and machine shops are numbered among power customers. In order to give prospective users an opportunity to convince themselves of the economy and advantages of electric power, the motors are installed on trial at a monthly rental, which applies toward the purchase of the machine. The result of this liberal policy is that comparatively few motors are removed after they have been once installed and tried.

The Janesville Electric Company maintains a display room with a large show window at their offices, and utilize this window to give working demonstrations of different applications of electricity. One of the recent displays was a motor-driven washing-machine and wringer in actual operation. The company announces such displays in the advertising columns of the local papers. The copy in these advertisements is changed frequently and the endeavor is made not only to catch the eye of the reader, but to tell him something interesting. A few of these advertisements are reproduced here.

One of the most interesting notices sent out by the Janesville Electric Company appears on the back of their bills. The first two clauses in this notice are well worth the attention of central station managers. A notice of this kind, backed up by the right kind of a man in the office to deal with dividend of good-will toward the com- customers, always results in a large pany.

New Principles In the Design of Lightning Arresters*

By E. E. F. CREIGHTON

Assistant Professor in Electrical Engineering, Union University, Schenectady, N. Y

LIGHTNING arresters are of the nature of an insurance. A certain percentage of the cost of the apparatus can be reasonably invested as a safeguard in protecting the apparatus. Furthermore, a percentage of the income can also be invested in protective apparatus as an insurance against interruption of service. The value of uninterrupted service depends upon the nature of the use of the current and will consequently vary in different plants. Plants which make contracts involving penalties or interrupted service naturally put a higher premium on good service. Protecting the insulation of the apparatus has been an easier matter than protecting the continuity of service. It has sometimes happened that the service has been interrupted by the action of the protective apparatus itself. This is especially true in the case of a grounded phase on an insulated delta or Y system.

It is the opinion of the writer that we have in view complete protection at the terminals of the lightning arrester apparatus against any high potential surge above 150% of the normal voltage of the system, regardless of the natural frequency of the surges and their duration of the application and also regardless of the cause of the surges. Direct strokes of lightning on a transmission line must of course be taken care of where they strike. Arresters at some distance away in the station can be expected to take care of only that part of the charge which reaches the station. How thoroughly a grounded overhead wire will protect the line from direct strokes has not been fully determined, or otherwise put, how many and what conditions of overhead grounded wires are necessary to protect the line against direct strokes of lightning is not definitely known.

Arresters can be built to take care of high-frequency surges, low-frequency surges, grounded-phase surges during an hour or so, and standing waves. This leaves the causes of interruption of the electrical circuit limited to short-circuits. These short-circuits may be limited to accidental conditions, such as a wire thrown across the transmission line, overheated apparatus, etc.

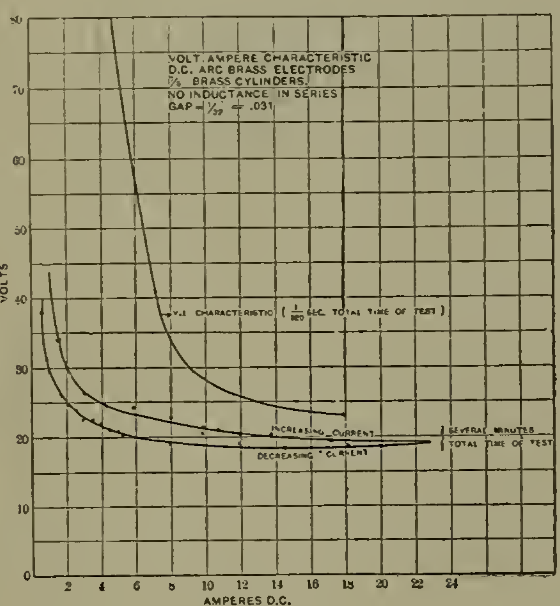


FIG. I.

ON THE DESIGN OF MULTIGAP ARRESTER.

The novel features of a new multigap arrester consist first, of the discovery of a true non-arcing condition of shunted gaps; secondly, a combination in a cumulative manner of several shunt resistances, and thirdly, the design of ohmic resistance by the volume method rather than by the radiating surface.

First: Absolute Non-arcing Condition. The term "non-arcing" has long been misused in the sense of arcing only during the brief time of a half cycle or only a few cycles of the generator wave. This action is more correctly described by the term rectifying. By the term "non-arcing" in the present application it is meant that the condition of sparking exists without the formation of an arc. Transition of a spark, where the conducting medium is the heated air, to an arc where the passage of electricity is accomplished by means of convection in the arc stream of zinc vapor, involves the expenditure not only of energy but also of power. The discharge of several hundred amperes for a brief period has been produced across a gap without bringing the difference of potential across the gap down to the normal value of 40 volts, corresponding to a current of one ampere. The power in this case was large as compared to the energy. In this connection brief periods approximating 1/100,000 second are considered. It seems to require an expenditure of power for a much longer time to bring the arc voltage down to even 100 volts. As the heating continues the voltage decreases. This effect is shown in Fig. 1. The voltage of any increasing value of current is higher than the voltage of the corresponding decreasing value (see the two lower curves). The difficulty in the initial transition from the condition of spark to the condition of arc is shown by another test on the same brass cylinders. Forty-five volts from a storage battery were applied to a 1/32-in. gap and a discharge of a Tesla coil was passed continuously across the gap for several minutes without causing an arc to form. In other words the battery gave out no energy. This is a case of a considerable energy at low power failing to cause an arc. It is seen from Fig. 1, however, if the impressed voltage of the battery is higher the arc will form and the arc voltage will drop far below 45 volts.

It is possible to discharge induced static electricity directly to ground without the intervention of resistance rods or wires and still prevent the dynamic current from the generator following, with the resultant short circuit. This condition requires the adjustment of the resistance in parallel with the gaps such that the current will be transferred through the resistance before the heat expended in the gaps is sufficient to bring the arc voltage to a low value. The

FIG. 2.

FIG. 2.—Combined non-arcing and rectifying arrester. The resistance on the near side of the gaps is of low value. It has cap contacts in the slips. The nine gaps in shunt with this low resistance are bridged by a static spark having an initial current value estimated at 1000 amperes. The spark has a clean-cut outline and illuminates the cylinders near it. In the four remaining gaps to the left the dynamic current is established by the same static discharge. The blurred impression of the arc is due to the sudden expansion of the zinc vapor. The resistance back of the cylinders has a high value and plays no appreciable part in the dynamic discharge. The nine gaps show the new principle of the absolutely non-arcing condition.

*Presented at the 217th Meeting of the American Institute of Electrical Engineers, New York, March 29, 1907.

problem is that of the instability of an arc (which is well known) under the unknown condition of volt-ampere characteristic of an initially established arc. The condition of instability of an arc and resistance in parallel will now be considered, using the volt-ampere characteristic (middle curve) of Fig. 1. This curve shows that the arc is extinguished by any resistance in parallel which reduces the current of the arc to about four amperes. Below four amperes the rate of decrease of current is less than the rate of increase of voltage, therefore the current will increase continuously in the shunt resistance, stealing away all the current from the arc.

The assumption is made that the total current is constant. This assumption is usually permissible. The value of resistance in parallel which causes the arc to become unstable depends on the value of total current;

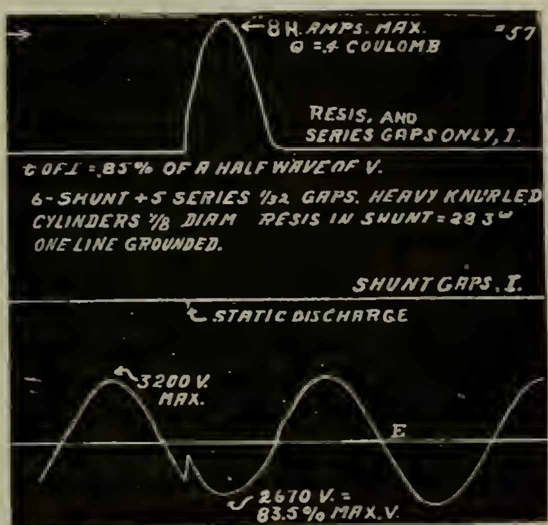


FIG. 3.

Fig. 3.—Oscillogram 57. Dynamic discharge when gaps are shunted to the absolute non-arcing condition. The upper curve is the current wave through the series gaps and low resistance. The middle curve shows the static discharge (and what little dynamic follows) in the shunted gaps. The lower curve shows the potential across the arrester inside the lightning arrester choke coils. The sudden drop in the voltage wave when the spark takes place is due to the regulation of the circuit. There is a 16 per cent. drop. The actual maximum voltage across the arrester is 2670 max. This is divided thus: 2590 volts across the resistance and 80 volts across the series gaps.

the higher the total current the less must be this value of resistance. For example, in the volt-ampere curve considered, if the total current is 10 amperes it requires four ohms in parallel to make the arc go out. If the total current is 22 amperes, the shunt resistance must be reduced to 1.3 ohms to extinguish the arc. If the total current is 500 amperes the resistance in parallel must be reduced to 0.05 ohms. This last-mentioned value is too low to be of practical importance. Lightning discharges may easily reach 500 amperes, but it must be recalled that the volt-ampere characteristic curve of the initial discharge lies far above the two curves given in Fig. 1, consequently a very useful value of a few ohms per gap will extinguish this spark before the dynamic arc can be established. The more favorable condition for the shunting of the gaps when the arc is just being started is shown in the upper curve of Fig. 1. The values of this curve were taken from an oscillogram of the voltage across one gap of an arrester during the brief period of a half cycle (1/120 sec).

Fig. 2 is a photograph of the combined discharge of static electricity and dynamic current. In the shunt gaps there is nothing but the spark, whereas in the series gaps both the spark and arc bridge the gaps. The arc is shown in the photograph by its greater size and explosive stream of zinc vapor.

Fig. 3 is an oscillogram of the currents of the two shunt circuits and the potential across the arrester when the factor of safety is diminished by having only six gaps in the parallel path. The potential across the arrester drops from 3200 volts maximum to 2670 volts maximum, due to the line drop and the regulation of the generator.

In order to avoid confusing the above described phenomenon with the usual familiar conditions of shunted mutigap, a distinction is herewith pointed out. The unstable condition of a shunted arc has been known for a long time; but this instability has to do principally with alternating current, whereas in this case only half a cycle of the generator potential is considered; in other words, we are treating the instability of a shunted direct-current arc during the initially brief period of formation.

Fig. 4 shows the phenomenon of extinction of arc by shunt resistance at the end of the first half-cycle. The arc in the series gaps was extinguished at the end of the second half-cycle. This is the effect previously obtained in shunt resistances where heavy currents were used. In this test the ohms per shunted gap were too great to suppress the initial arc.

There is still much research to be done to determine the exact nature of the phenomenon at the instant of establishing and extinguishing an arc. Most of the results are of academic interest only. Here are some queries. In the extinction of the arc in the series gap at the end of the half cycle in which the discharge takes place, how much effect is due to rectification of the zinc vapor and how much to the cooling of the arc during the brief period of zero current? The answer is not simple, we know. For small currents, the effect is almost entirely due to cooling; for large currents, rectification by the zinc vapor is more

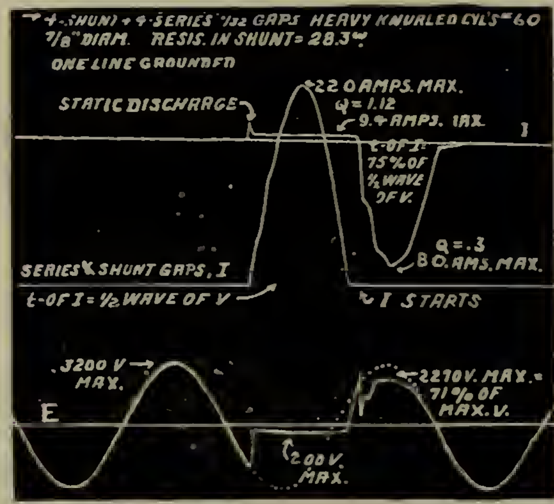


FIG. 4.

Fig. 4.—Oscillogram 60. Failure of shunt resistance. Former "non-arcing" condition. There are only 4 gaps in shunt 28 ohms. The upper curve is the current through the resistance. Note the point marked "static discharge," the current in the resistance starts at a value greater than can be maintained. The current in the resistance is equal to the voltage across the shunt gaps divided by the resistance. This peak value bears out the statement that both energy and time are necessary to form a stable arc of normally low voltage value. The middle curve shows nearly short-circuit condition of the circuit. Note that this current lags the potential while the current in the wave above with resistance in series is in phase. The lower curve, the potential wave, shows the condition of sensibly short-circuit in the first half-cycle and the recovery in the second half-cycle. Note in the second half-cycle that the voltage jumps to about 2500 volts before the current is reversed in the series gaps.

prominent. The distinction is liable to be obscured by the two auxiliary accompanying conditions—first, the ionization of the air around the zinc arc and, second, by the splashing across the gap of the superfluous molten metal in the crater of the arc. Some years ago Mr. Thomas stated that it was necessary to limit the current in a multigap arrester in order to get successful operation and also that the extinction of the arc was accomplished with greater difficulty if the circuit was inductive. The explanation of these facts have a practical bearing on the matters given further on in this paper.

Current Effect.—The extinction of an established arc in a multigap arrester cannot take place until the potential reduces to zero at the end of the half-cycle in which the discharge takes place. Incidentally it may be remarked that if the arrester functions properly the arc should not extend over the second half-cycle. (Assuming no high potential surge re-establishes the arc). If the rectifying power is not sufficient to extinguish the arc at the end of the first half-cycle, it surely will be unable to do so at any instant later on account of the heated metal in the arc crater. (See Fig. 9.) Consequently such an arc can be extinguished only by the flashing out of the multiarcs in one long arc in front of the arrester unit, the opening of the circuit elsewhere by a fuse or switch, or by the decrease in the generator electromotive force. This decrease in potential will be due to the reaction of the armature current on the field winding. Assume then that the arrester functions properly, and furthermore that the spark takes place on the rising point of the electromotive force wave, this gives the greatest possible discharge of dynamic electricity. The energy loss in each arc will be equal to 16 volts multiplied by the current. In other words, as the current increases there is a concentration of energy at the arc crater which melts more zinc than is necessary to supply the arc vapor. This molten zinc is splashed across the gaps and destroys the rectifying qualities of its vapor.

In consequence of the necessity of limiting the dynamic current, some designers have chosen between two evils and introduced series resistance into the arrester circuit. Other de-

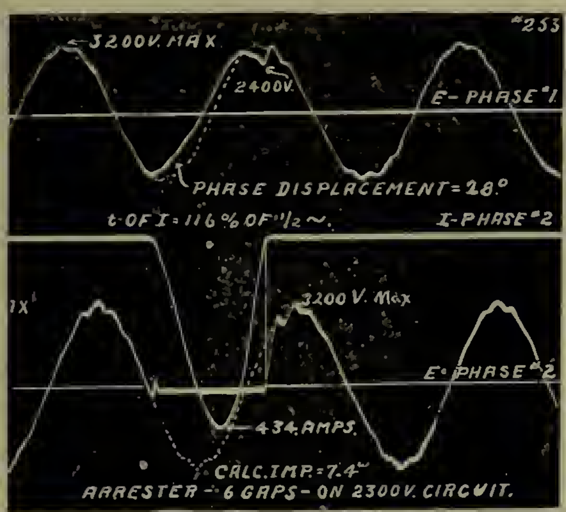


FIG. 5.

FIG. 5.—Oscillogram 253. Showing current lag, sudden recovery of potential, and displacement of another phase of the system. In the lower curve note the potential recovery when the current is extinguished. The dotted curve shows the orginal form of the wave. The middle curve shows 434 amperes short-circuit current. There were 3 miles of line wire to the generating station. The upper curve shows the phase displacement in phase 1 due to the reaction of the armature current in phase 2. It is noteworthy that the voltage wave of phase 1 did not have a peak value above normal maximum of 3200 volts during this interval.

signers choose the evil of a possible short circuit. One improvement in design for this year is the use of a shunt resistance so proportioned as to

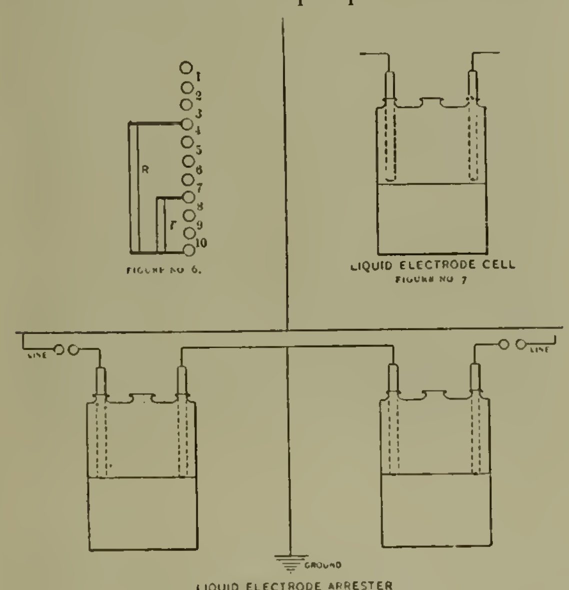


FIG. 8.

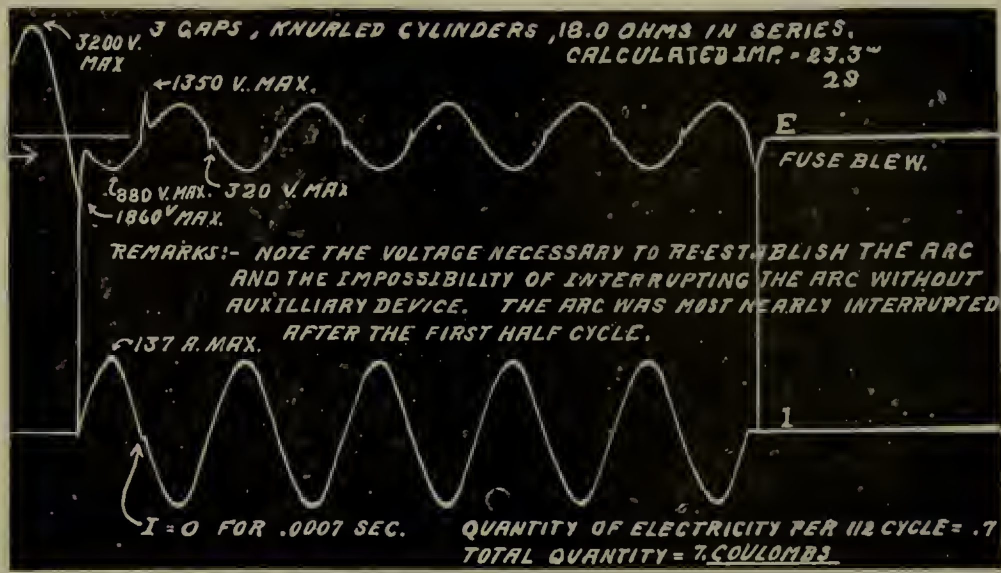


FIG. 9.

FIG. 9.—Oscillogram 29. Three gaps and 18 ohms on a 2300 V. (effective) circuit. Arrester fails to interrupt the current of 137 amp. maximum. If the arc is not extinguished at the end of the first half-cycle, the rectifying effect is lost. The spark takes place at 1860 volts increasing potential. The voltage then drops due to line resistance, etc., and reaches 880 volts max. instead of 3200. At the end of the first half-cycle the potential rises to 1350 before the current is reversed. At the end of the second half-cycle it requires only 320 volts to reverse the current. At the end of the first half-cycle on the current wave, the current remains zero for a brief period. This effect does not reoccur at the end of any subsequent half-cycle. If the current had been less three gaps would have extinguished the arc at the end of the first half-cycle.

prevent the dynamic current flowing in its parallel gaps, yet allowing a high-potential, high-frequency discharge to pass freely across the shunt gaps to ground, if the resistance offers an objectionable impedance. There is resistance for the dynamic but no resistance for heavy static discharges.

Inductive Circuit Effect.—Oscillograms show that if the arrester circuit is inductive the arc is not extinguished until the potential has passed through zero and is well along in the second half-cycle. Since the arc voltage is only 16 volts per gap for heavy currents the condition is nearly equivalent to a short circuit. When the current dies out the voltage across the gaps suddenly jumps to the value generated. (See Fig. 5.) The arc has no time to cool and presumably the ionized air around the arc starts the current in the opposite direction. This condition is to be compared later to the condition of arc extinction in the liquid electrode arrester, where the current reduces to zero before the potential.

2. Cumulative shunt resistance. Referring to the diagrammatic condition of Fig. 6, gaps Nos. 7, 8, 9 and 10 are protected from dynamic current by the relation of the shunt resistance (*r*). The resistance (*r*) is small and requires, say, six series gaps, Nos. 1, 2, 3, 4, 5 and 6 to extinguish the dynamic arc. Under certain low-frequency conditions of discharge, this number of series gaps is objectionably great. Consequently this number is cut down to, say, three gaps, Nos. 1, 2 and 3, an din order to extinguish the dynamic arc at the end of the first half-cycle the current must be less than that through the small resistance (*r*); the relation of the larger resistance

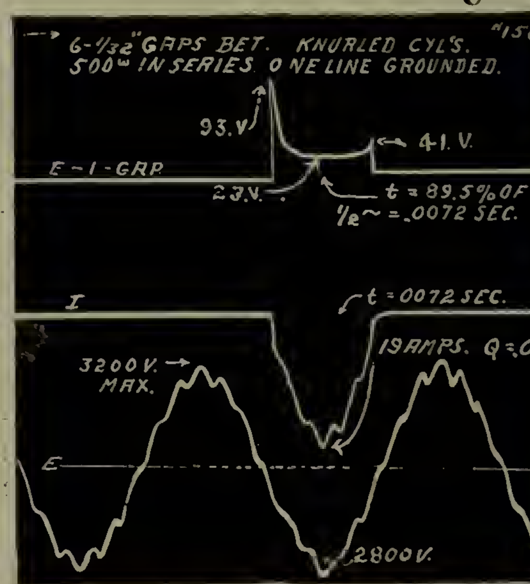


FIG. 10.

FIG. 10.—Oscillogram 156. Voltage and current of one gap of a multi-gap arrester. The oscillogram shows an initial voltage of 93 volts. The drop from spark voltage to 93 volts was too rapid to be registered by the oscillograph vibrator. This sudden drop in potential was due to the heavy discharge from Leyden jars at a frequency estimated at 3,000,000 cycles. The decrease in voltage from 93 to 23 volts is very gradual with this value of current density. The upper volt-ampere characteristic curve of Fig. 1 was taken from this oscillogram.

(*R*) to the gaps numbered 4 to 10 inclusive is not such as to obtain the arcless condition of the gaps. The arcless condition of the gaps 4, 5 and 6 is obtained through the presence of the small resistance (*r*) in shunt with the large resistance (*R*). So far as the large resistance R is concerned, gaps 8, 9 and 10 cannot be considered in the shunted circuit. In this cumulative manner of installing the resistance, the series gaps may be reduced to as near the spark potential of the normal circuit voltage as desired. Each time the series gaps are reduced, the resistance must be increased to such a value as to maintain the arc extinguishing effect.

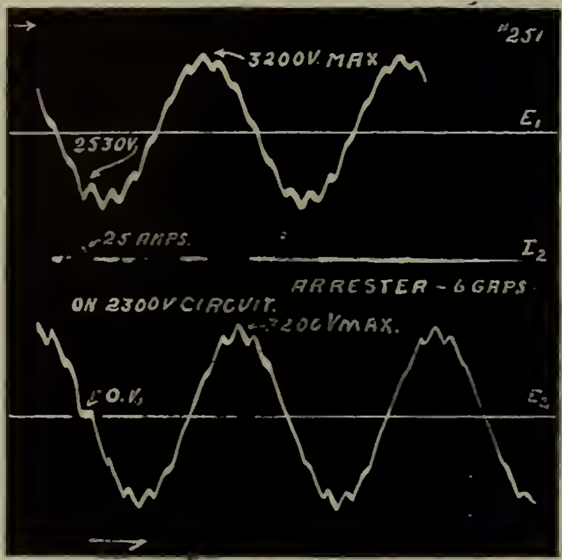


FIG. 11.

FIG. 11.—Oscillogram 251. Six gaps and no series resistance on a 3-phase circuit of 2300 volts effective. The middle and lower curves are of the same phase. These show a discharge of dynamic current where the spark takes place on the descending part of the potential wave. In spite of the short-circuit of the gaps the dynamic current rises only to 25 amperes. In practice the spark may, of course, take place at any point of the potential waves. In a poorly designed arrester if by chance the spark should happen when the potential is approaching zero the arrester will extinguish the arc satisfactorily; if, on the other hand, the spark takes place on the rising potential the effect may be that shown in Fig. 9. This oscillogram shows the futility of testing arresters without a synchronous switch to control time of spark discharge.

Design of Lightning Arrester Resistance.—Except in the case of recurring high-potential surges, the multigap arrester should extinguish the dynamic arc within the time of a cycle of the generator wave. This period of time is so brief that radiation of heat need not be considered in the design of the resistance. The

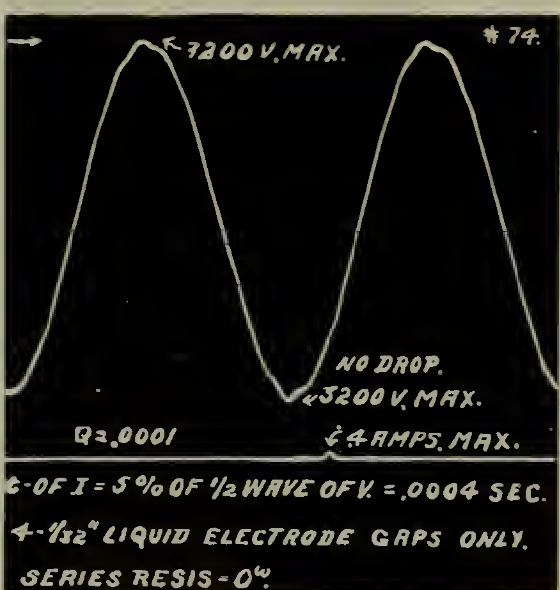


FIG. 12.

FIG. 12.—Oscillogram 74. Liquid electrode arrester using gaps at the surface of the electrolyte. Two cells in series. The current rises only to 0.4 amperes and there is no disturbance in the potential wave.

basis of design is the utilization of the specific heat or the heat capacity of the resister. In the lower resistances of the lightning arrester it would be impracticably expensive to design the resistance to radiate the energy that would be lost therein if the current were applied even for several seconds.

E^2 over R multiplied by the time of a half-cycle gives the energy to be absorbed. This value of energy must equal the product of the specific heat times the weight of material times the temperature times 4.2.

Assuming a safe temperature and factory of safety, the weight of the material can thus be determined.

The specific resistance of the material must be chosen so as to give a length of rod great enough at least to prevent the formation of an arc along the surface. In the matter of selection of material for the resistance, notable improvements have been made.

LIQUID ELECTRODE ARRESTER.

This arrester may have any one of several forms all involving the same principal. One form is shown in Fig. 7. Two metallic electrodes extend into a vessel containing an electrolyte of high conductivity. The electrodes may be dipped into the electrolyte or there may be a small gap left between the electrode and the electrolyte. If current is passed from one electrode to the other in either direction, the liquid must become negative at one or the other electrode. It requires about 1500 volts to maintain the current through the cell in spite of the fact that the resistance of the cell is extremely low. The current is limited by the so-called counter electromotive force of the arc.

Electrodes not in Contact.—The difference in effect produced by the conditions of contact between the electrodes as compared to the air-gap setting is marked. For example, three of these cells were placed in series across a circuit having an impressed voltage of 2300 volts effective. Each electrode was set with a small gap. The equivalent needle gap was the same as for four $^1/_{32}$-in. gaps between standard brass cylinders without series resistance. With this arrangement several hundred static discharges having an initial value estimated at 1000 amperes were passed through the cell, but no dynamic current followed the discharges. The novel relation of counter-electromotive force practically as great as the spark voltage of the cell is obtained. The sum of the counter-electromotive forces per cell is greater than the impressed voltage of the circuit, consequently a spark passes without causing the formation of an arc.

Under similar conditions in the multigap arrester using four $^1/_{32}$-in. gaps the spark voltage of a single gap may be in the neighborhood of 2000 volts and the spark voltage of the four gaps in series may lie between 5000 and 6000 volts. The electromotive force absorbed by a single arc in practice will be scarcely greater than 16 volts per gap or 70 volts total for the four gaps. The spark voltage is about 125 times as great

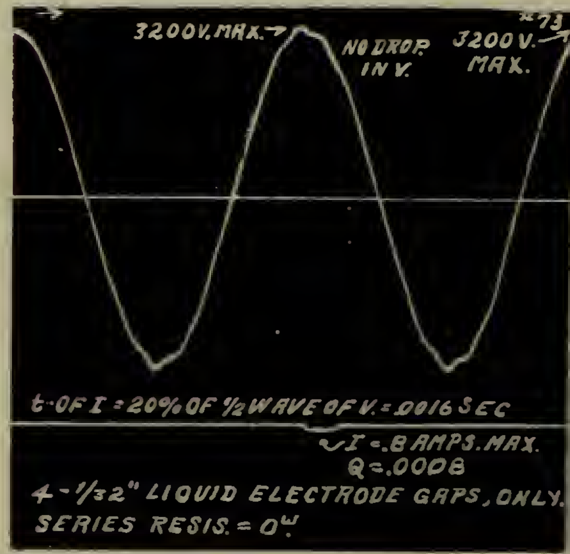


FIG. 13.

FIG. 13.—Oscillogram 73. Liquid electrode arrester using gaps at the surface of the electrolyte. Although the spark takes place at peak voltage only 0.8 ampere of dynamic current follows. Comparing the current discharge to Fig. 12, the current is twice as great and persists for a longer time. This is due to the fact that the discharge takes place at a higher point on the potential wave. The counter e.m.f. of the cells is approximately equal to the peak voltage (3200 volts) of the circuit. There is no disturbance of the potential wave.

as the arc voltage for a single gap or about 80 times as great for the total of the four gaps.

Herefrom it follows that the multigap arrester does not work on the principle of counter-electromotive force but upon the principle of rectification. The arrester is therefore suitable for alternating-current circuits but not at all adapted to direct-current circuits. When the currents attempt to reverse at the beginning of the second half-cycle, several hundred or even thousand volts may be required to cause the reversal. During

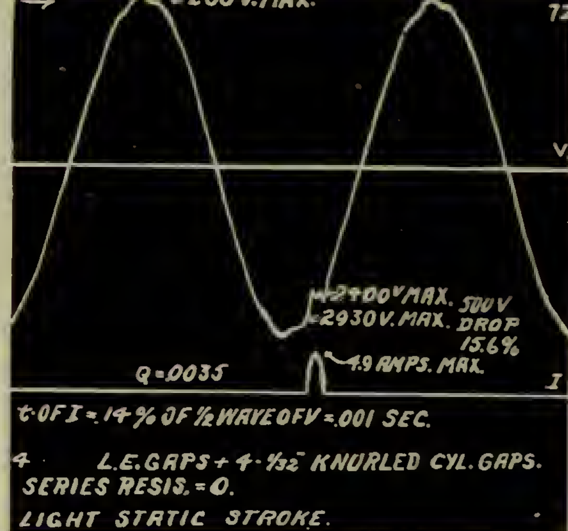


FIG. 14.

FIG. 14.—Oscillogram 72. Liquid electrode arrester using series gaps in conjunction with the small gaps above the electrolyte. There were two large lightning arrester choke coils of the pancake type in series. These coke coils give the exaggerated drop of potential (500 volts) at the instant of discharge.

the first half-cycle it is necessary to have an artificial resistance in series to limit the dynamic current.

A liquid electrode arrester set with four gaps of equal value to the above-mentioned case will have a spark voltage of $1^1/_3$ times as great as the electromotive force absorbed by the arc, considering a single element only; or about 1.8 times as great considering

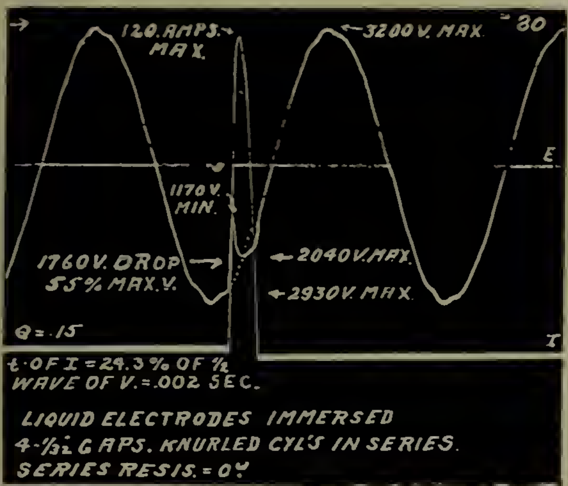


FIG. 15.

FIG. 15.—Oscillogram 80. Liquid electrode arrester with immersed terminals. The heavy lightning arrester choke coils are in series. These reactance coils add to the line drop of potential. This oscillogram shows a method of obtaining any desired quantity of dynamic discharge before the interruption of the current. The current has increased from 0.4 ampere (Fig. 12) to 120 amp. maximum due to the immersion of the metal terminals. In spite of this heavy current discharge the current decreases to zero before the potential reaches zero. Compare this to the results in Fig. 5 where the potential reaches zero and reverses before the arc is extinguished.

both cells. On a 2300 (effective) circuit the maximum voltage is about 3200 volts. The maximum arc voltage of the two cells containing a particular electrolyte is about 3000 volts. A spark can form into an arc only at the peak value and is extinguished long before the generator voltage reaches zero. Any voltage above 1500 volts per cell produces a rush of current in proportion to the pressure

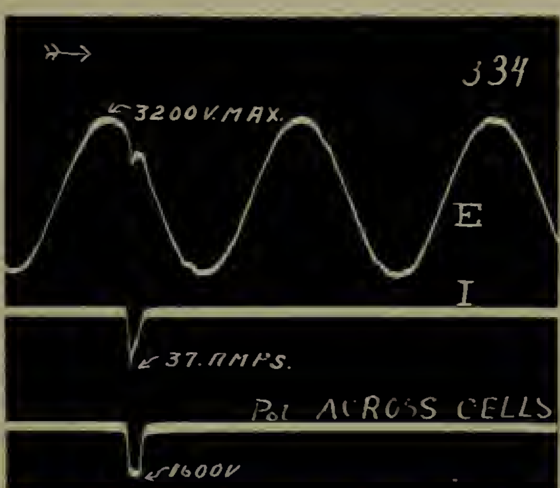


FIG. 16.

FIG. 16.—Oscillogram 334. Liquid electrode arrester with the metallic electrodes slightly in contact. The upper curve, the potential wave, is only slightly distorted. The middle curve, the current wave, rises rapidly to 37 amperes and diminishes gradually to zero. The lower curve, the potential across the cell, rises with the same abruptness as the current wave, maintains a constant value while the electromagnetic energy of the circuit is discharging and then drops quickly to zero when no longer required to oppose the current discharge.

above 1500 volts. In other words, the cell has a critical voltage above which there is a free discharge of electricity without the intervention of anything more than a slight ohmic resistance. In the foregoing explanation only general considerations have been held in view. Some of the experimental data from which tne conclusions were drawn are given later in the form of oscillograms.

Electrodes in Contact.—When the metallic electrodes touch the liquid it is necessary to introduce a single gap in series to hold back the line potential. Since the counter electromotive force of arcs in the arrester limit the current, this single gap suffices even at the high potentials used

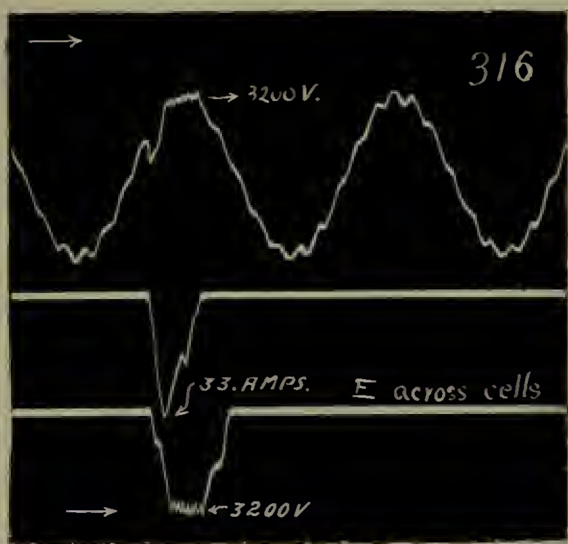


FIG. 17.

FIG. 17.—Oscillogram 316. Liquid electrode arrester with the metallic electrodes in contact with the electrolyte. The static discharge takes place on the rising part of the potential wave. The drop in the upper potential wave is due to the inductance of the circuit. The potential wave quickly recovers its normal form. The current reduces to zero in advance of the potential. The potential across the cell reduces to zero with the potential of the generator wave. The maximum counter electro-motive force of the cells is equal to the impressed voltage of the circuit.

on long-distance transmission circuits. A simple arrester circuit is shown in Fig. 8. The series gaps may be set at any value above line potential. When the potential breaks across the gaps the current begins to discharge at short-circuit rate. The current density at the electrodes is such as to start an arc which throws the electrolyte away from the electrode and automatically lengthens the arc. The arc voltage is greater than the impressed voltage and the current dies out. The series gaps hold back the line voltage. The electrolyte assumes again its level in contact with the electrode. The current starts on short circuit but decreases so gradually that no surges have been detected either by the oscillograph or by parallel needle gaps. Extensive experimental tests have been made on a commercial circuit of 2300 volts, 13,000 volts, and 33,000 volts normal voltage. The last-mentioned circuit consisted of 30 miles of

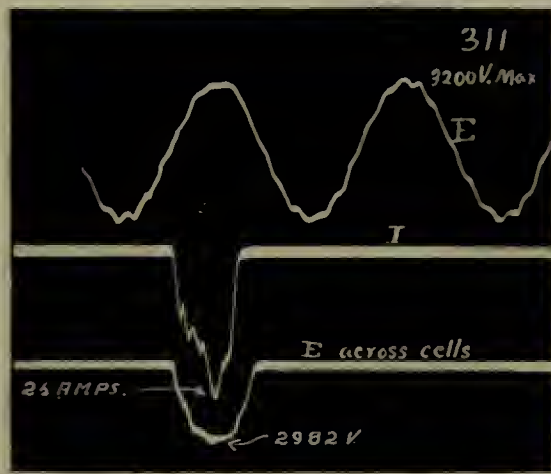


FIG. 18.

FIG. 18.—Oscillogram 311. Liquid electrode arrester with the metallic electrodes in contact with the electrolyte. The spark takes place near the zero value of rising potential, consequently the rise in current and potential across the cells is more gradual than in the previous oscillograms.

three-phase line and was subjected to surges, due to numerous arcs drawn out between a phase and ground. These arcs to ground attained maximum lengths of five feet.

The arc voltage of the liquid electrode depends somewhat upon the length of the arc. Since it is the current which depresses the surface of the electrolyte, the length of arc de-

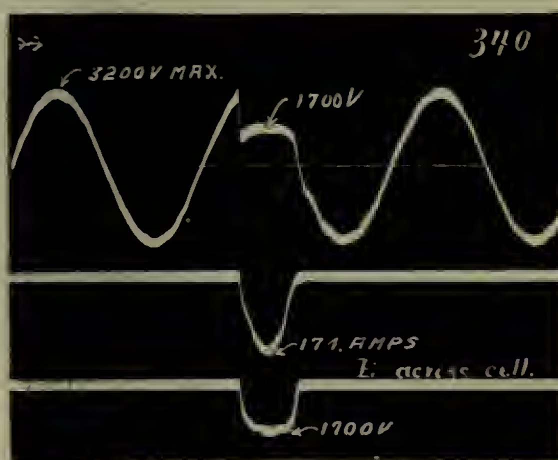


FIG. 19.

FIG. 19.—Oscillogram 340. Illustrating the critical limiting value of cell voltage. There is but one cell on a 3200 volts (max.) circuit. The spark takes place at about 3000 volts and the potential drops to 1700 volts and remains sensibly constant during the rest of the half-cycle in spite of the capacity of the generator to which it is connected. The current rises to 174 amp. maximum. This cell acts as a short-circuit for pressure above 1700 volts, but is active in opposing the current flow as soon as the pressure falls again to 1700 volts.

pends greatly upon the value of the current. As the current decreases the electrolyte rises toward the metallic electrode. After the first instant the phenomena are of the nature of cushion effects.

The quantity of electricity which passes through the arrester before the electromotive forces absorbed by the arcs becomes active, depends upon the amount of surface of metallic electrode exposed to the liquid. This value can be increased by immersing the metal to a greater depth.

The resistance of the arrester is located initially in the liquid only but

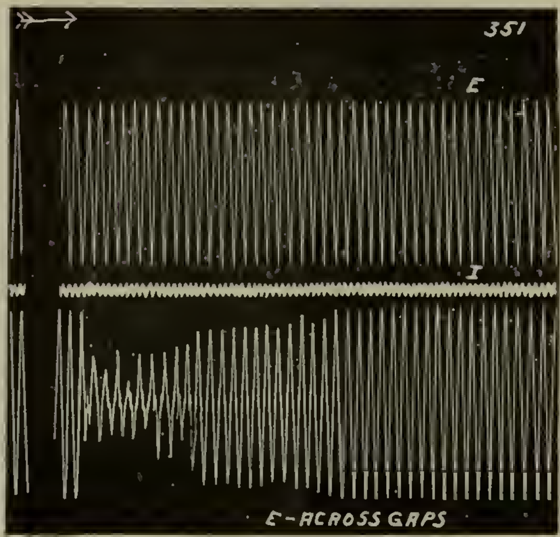


FIG. 20.

FIG. 20.—Oscillogram 351. The recovery of a liquid electrode arrester after a lightning discharge. The upper wave is the potential across the entire arrester. The lower curve is the potential across the series gaps alone. The middle wave is that of the current of discharge. The actual wave is not visible on account of poor illumination of the mirror of the vibrator, but the duration is shown by the open space in the zero line of current during the third cycle after the opening of the shutter. The potential curve across the gaps shows a drop to zero, then a gradual recovery to full line potential. During this interval the arrester is ready for a second discharge.

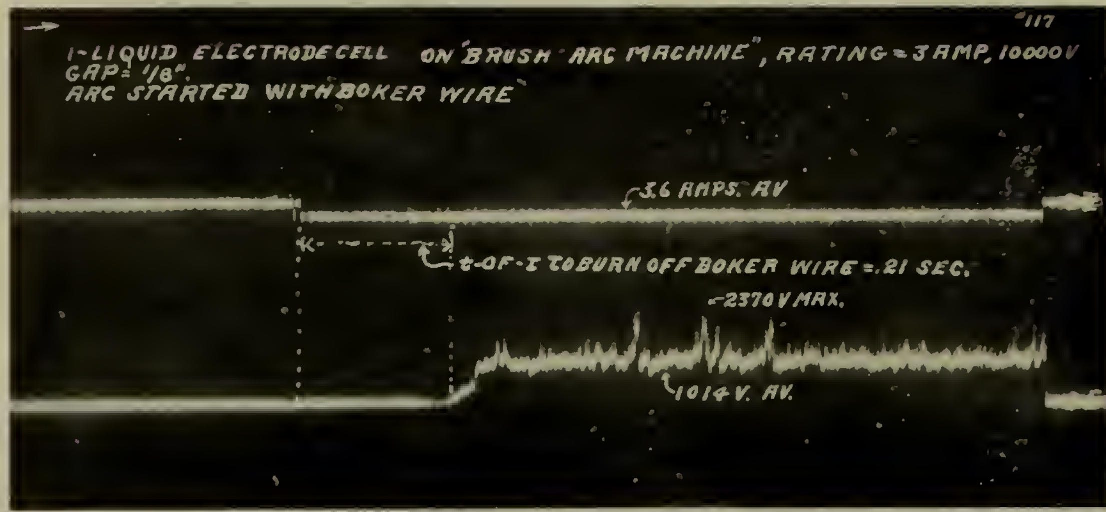


FIG. 21.

FIG. 21.—Oscillogram 117. Liquid electrode cell on 3.6 amperes constant current. The voltage varies considerably, due to the splashing of the electrolyte. The small lumps in the current wave are due to the irregular intensity of the oscillograph arc. The average voltage for this electrolyte and current is approximately 1000 volts. The arc was started by means of a 5 mile Boher wire. It required 0.2 sec. to burn off this fuse with the current at 3.6 amperes.

gradually divides between the series arc and the electrolyte. The electrolyte is a large body of large cross-section and low specific resistance.

The electromotive force absorbed by the arc at the electrolyte varies somewhat with the nature of the electrolyte.

Although the initial current may be considerable, the total current in continuous operation is not. To determine the endurance of the arrester, a 13,000-volt unit was connected to one phase of a circuit without any series gap or resistance. This circuit consisted of a 2000-k.w. generator connected to nearly a mile of cable and seven miles of overhead line. The other two phases were protected by gaps set at 150% of line voltage. The potential of these phases did not jump the gaps during the severest tests. It should be noted that the arrester was in action under the abnormal condition of no series gaps. The action of the arcs gradually lowered the level of the liquid until 13,000 volts would no longer maintain the arcs. The

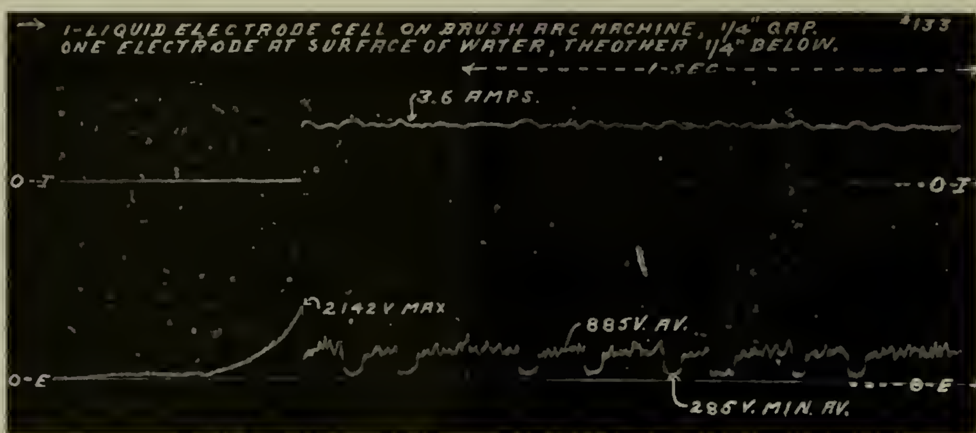


FIG. 22.

FIG. 22.—Oscillogram 133. Liquid electrode cell on direct current showing the time required for the arc to bore ¼ inch below the surface of the electrolyte. The average potential with the liquid as the negative electrode in 885 volts, but when the arc reaches the metal electrode in the liquid the voltage drops to 285 volts or less. Shortly after the liquid again sweeps over the lower metal electrode and raises the voltage again.

time required to do this depends on the construction of the cells. In the small cells it is about five minutes and in the large cells somewhere between ten and twenty minutes. This time can be increased if found advisable. This sustained operation should make the liquid electrode arrester suitable to take care of the recurring surges on an isolated delta or Y system, when one phase is grounded through more or less of an arc, during a time amply sufficient to disconnect the faulty line. In the foregoing experiment a 20-ampere fuse in series with the arrester was unaffected. Apparently the possibility of an interruption in practice due to the short circuit of the arrester can be eliminated as it was in this test.

In practice the number of cells would be chosen to give a critical limiting voltage of 125% to 140% of the impressed voltage. The gap length may be set to give any desired protection. Since the arrester has but a single gap, the spark potential is as near independent of the natural frequency of the lightning surge as possible. It should discharge with facility low-frequency surges. It has a small dielectric spark lag.

The characteristics of the liquid arrester have been studied in detail with the aid of an oscillograph. A few oscillograms have been chosen which show the effect of a cell on the current

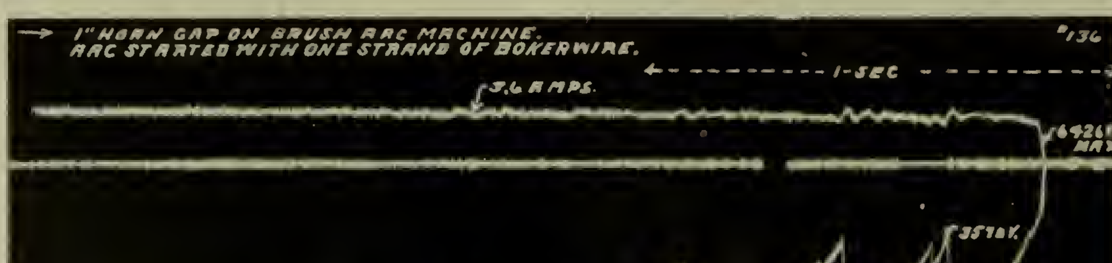


FIG. 23.

FIG. 23.—Oscillogram 136. Potential of a horn gap discharging 36 amperes constant current. The arc rose up the horns with considerable difficulty. The are would flame to a peak and the potential would strike across below the peak and thus shorten the total length of the arc. The shortening of the arc would drop the potential. This effect is shown in the lower curve of the oscillogram by the repeated drops in the potential. The arc held in the narrow gap for about a second. This is shown by the low voltage of the curve. The total time the arc held was two seconds.

and potential of a commercial 2300-volt circuit. Among other things shown in these oscillograms are:

The effect of discharge at different points of the potential wave.

The effect of more or less immersion of the metallic electrode on the current and potential.

The critical limiting voltage of different electrolytes.

The critical limiting voltage of the arc in the standard multigap arrester (this is given for comparison).

The initial short-circuit effect and subsequent cushion effect.

The recovery of the cell after the discharge.

The reduction of current to zero before the potential wave reaches zero.

The writer pays his grateful homage to the originator of the oscillograph, M. André Blondel. The value of the oscillograph in this work will be evident from an inspection of the oscillograms. The auxiliary apparatus necessary to get initial effects of discharges is quite essential. The problem is to place on a revolving photographic film with a total time of exposure of about $^1/_{10}$ second, a static spark which will start the dynamic current flowing at any chosen point of the potential wave not varying in location by more than about 1/1000 second. In the following described combination of switches the operations are entirely automatic. It requires only the release of a latch. The oscillograph is so constructed that a lever operates the shutter. The shutter is opened by the lever and closed

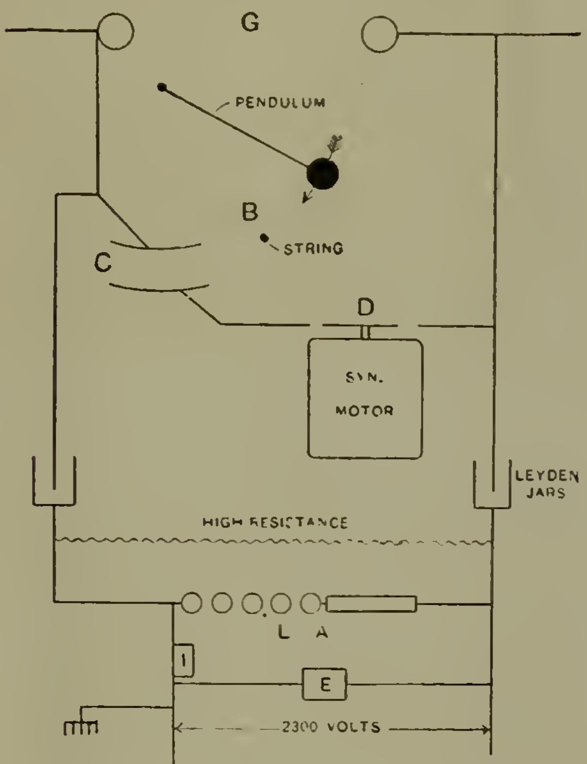


FIG. 24.

by a complete revolution of the drum carrying the photographic film. Fig. 24 shows the connections and locations of the apparatus. When the pendulum is released it strikes a string at *B* which opens the kodak shutter; it then closes the circuit between the two parallel strips during an interval depending on the velocity of the pendulum and the length of the strips. Meanwhile the synchronous motor carrying the synchronous switch at *D* closes the circuit of the static machine located at *G*. This release of the potential on the inner coatings of the Leyden jars throws the potential on to the lightning arrester *L A*, thus producing a spark across the gaps. An arc follows from the dynamic potential which is also impressed on the terminals of the lightning arrester. The vibrators of the oscillograph are shown at *E* and *I*. The static machine is kept running at such speed that it will not spark across the gap at *C*. The potential of the static machine is also easily controlled by the application of more or less needles. These needles can be regulated to discharge the current of the static machine as rapidly as it is generated. The potential can thereby be limited to any desired value.

Institute Discussion of Lightning Protection

IN opening the discussion of the papers presented by Dr. C. P. Steinmetz, Messrs. Rushmore and Dubois and Professor Creighton at the March 29th meeting, Dr. F. A. C. Perrine said in referring to the paper by Dr. Steinmetz: "We have as yet to discuss what occurs when we have two sets of waves on a long transmission line, started from different points on the line and coming together. Aside from the increased constants, capacity and self-induction, of the long-distance transmission line, I think we will have some additional difficulties due to the fact that in a long-distance transmission line, covering a great area, there may be a storm in a certain part of the line and clear weather in the remainder of the line, or we may have two independent storms in different parts of the line, giving us lightning effects which induce waves which meet and combine, and increase the effects. Otherwise, we would not have the great difficulty there is before us now of our being able to protect fairly well long and extensive low potential line. When we string that line out in series to a greater extent of territory, we have, as we all know, a very much more difficult problem."

As regards the second paper, I am inclined to disagree with the presentation of the case of the horn arrester. The real theory adopted by those who have used the horn arrester, is largely left out of this criticism of the horn arrester. The horn arrester, where used successfully, has been used on the principle that the wave trains in themselves produce potentials which will break down the insulation of high-potential lines. The principle is that we had better spend our money in erecting our lines in such manner as not to make the insulation subject to the wave trains of relatively low potential, such as we would have to guard against in our lower potential lines, and the horn arrester is introduced with the idea of saving the apparatus from destruction where any other form of arrester would not itself be destroyed, and even if protected, the machinery would leave the line open for damage in the further continuance of the storm. That is a condition which has been frequently met in the introduction of the multigap arrester even of the best forms. When we get the extreme cases, which Dr. Steinmetz has described, of the short-circuiting potential and discharge across the arresters of extraordinarily high energy, the multigap arresters generally fail and the line is then left unprotected even if the machinery is safe. The horn arrester is introduced in such cases as being able to take care of these great discharges, and while possibly giving trouble with the synchronous motors on the line by its long interruption, it has saved the apparatus and itself as well."

At the last meeting of the Institute we had, referring to this lightning problem, Mr. Mershon describe his system of horn arresters with varying resistances in series with a group of horn arresters. If I remember correctly, he said he used five sets of horn arresters, each of a different value of resistance in series. That system has had, say, a year of operation at Niagara Falls, and while it has shown that the system of protection is not complete and requires for certain types of discharge that comes from the line a set of multigap arresters, in connection with the horn arresters situated probably inside the station, so that if any of the high-frequency discharge passes, the horn arresters will discharge over the multigap arresters and these high-frequency discharges, of the nature of the wave train that Dr. Steinmetz described, are discharged over the multigap arresters harmlessly; at the same time the horn arresters in that connection discharge the low periodicity surges, which are the surges which are usually destructive to the multigap arrester. In this I particularly disagree with Mr. Rushmore and Mr. Dubois, as they seem to indicate that it is their belief that the horn arrester is better adapted for discharging high-frequency discharges. As a matter of fact, the opposite is true, as is explained in his own paper, and more particularly in that of Mr. Creighton, that the higher the frequency discharge the more rapidly is it carried over the multigap arrester. The low-frequency discharges are not as well taken over the multigap arrester, whereas over the horn arrester the low-frequency discharge is more rapidly taken than over the multigap arrester.

I think the best protection we have is a combination of the horn and multigap arrester; the multigap arrester to take charge of the relatively high-frequency discharges, and the horn arrester to take charge of the low-frequency discharges.

As regards Mr. Rushmore's and Mr. Dubois's construction of a pole-head to take care of the overhead ground wire, I think there is some very serious criticism to make. In the first place, the pipe shown is an extremely bad piece of engineering. The connection of the pole for the amount of leverage shown there is not good, and I confess that for the present I cannot see how a workman is going to attach a ground wire, ⅜ inch in diameter, to the top of that horn arrester, unless he is let down from a balloon, and there is some means provided in pulling up the wire to prevent the dead end not being pulled over. As regards the guard wire put on them, as I understand, for the purpose of being a horn arrester to protect the insulator, I cannot see how that particular form of arrester will do other than hold the arc. If an opposite horn were brought out from the line, and a horn arrester made there, it would discharge and protect the insulator. In the same connection, he speaks of the specification for this overhead wire. I have always believed that a barbed wire, if made properly, is a better means of line protection than a smooth wire, at the same time I question very much whether a satisfactory barbed wire can be made. I prefer very much a ⅜-inch stranded steel wire by which, I understand from this, the ordinary common guy line, made of the best kind of Bessemer steel, with a 3-wire ¼-inch strand of high-grade steel, would stay up.

The treatment of the multigap arrester adds considerable to our knowledge of the manner of action of this arrester. I think, however, that the subject is treated more completely in Mr. Creighton's paper than in Mr. Rushmore's, because he explains more particularly the influence of the rectifying effect of the non-arcing metal—to go back to Wurtz's term—and the capacity effects described in Mr. Rushmore's paper are simply in addition to the effect of the series resistance or shunt resistance, and in addition also to the rectifying effect of the metal in the gaps, and metal which will rectify is absolutely necessary for the success of the multigap arrester. I do not think that the function of the resistance in connection with the multigap arrester has been before as clearly explained as Mr. Creighton has explained it, in which he calls attention to the fact that there is really no radiation from the resistance in such an arrester, and we must take into account in forming such resistance, the specific heat of the material and the extent of the metal that it may absorb the energy. At this time, and as I believe for the first time, our attention has been called to the fact that the radiation of the resistance is relatively unimportant.

As regards the electrolytic arrester, we seem to have an entirely new form of electrolytic arrester. I will call your attention to the fact that in the last number of the *Electrician* (London), there is a very complete description of the electrolytic arrester invented and patented and somewhat used in England by Ferranti, which is not of this type, but is, if I understand correctly, the type described at the last lightning-arrester meeting by Mr. Jackson. Ferranti is one of those men who is always inventing things before people are educated enough to use them, and he abandoned his patent for the reason that he could not get it used, although the experiments indicated the arrester was a very successful one indeed. This principle Mr. Creighton has described here of the actual striking arc in the electrolyte, and so obtaining the benefit as a resistance of the counter electromotive force of the arc is very important indeed. It relies for its action on the formation of an arc within the arrester, which I suppose would very rapidly evaporate the electrolyte and the cells would require considerable watching in order to keep the electrolyte surely at a certain particular level.

In Mr. Creighton's paper he shows us the benefit of the oscillograph in the study of lightning-arrester problems, and that benefit is probably greater in these problems than in other classes of problems we have met. As Dr. Steinmetz aptly said, "lightning-arrester problems cannot be efficiently studied in the laboratory." At the same time, our somewhat restricted methods of work in the laboratory can better be explained and extended to practical use by study through the means of the oscillograph than by any other possible methods of study. The laboratory work on the electrolytic arrester of Mr. Creighton, shown here, is of great importance, particularly because he shows his arrester as a single gap arrester, in other words, a horn; and at the same time he shows how the horn can be set close enough together so that it will take care of the high-frequency relatively low-potential discharges as well as the low-frequency high-potential discharges, and this gives practically a single-horn arrester with a variable resistance in series, which is all that the horn arrester needs to become the best arrester of any that can be made. Furthermore, the electrolytic arrester puts what amounts to practically a variable fuse in the circuit, as well as a variable resistance, and it gives us also a replaceable fuse. The necessity of the fuse at all is the greatest criticism, in my mind, that can be made of the arresters shown by Mr. Rushmore. These arresters all have fuses in them. If they are meant to blow, I feel quite sure that all operating men here will agree with me that in a serious thunderstorm, such as we have in the South or in the Colorado region, they will never be replaced after they have once blown during that storm. I do not know of any man with nerve enough to go near the arrester to put in a new fuse. This substitution of a variable resistance counter *e. m. f.*, and a variable fuse and single-gap arrester, which is described by Mr. Creighton, is, to my mind, the practical solution of the lightning-arrester problem, and I believe if this thing is worked out commercially we will be many miles nearer the complete solution of the lightning arrester problem than we have ever been before."

Mr. Farley Osgood, of the New Milford Power Company, said:

"Experience seems to show that lightning-arrester protection is an individual study for each individual plant and for each individual locality.

In talking with other operating engineers I find that they use quite different means of protection from the ones we use, and they are equally successful or unsuccessful. Each man seems to have his own ideas about it, and I think the lightning-arrester problem, like some of our other problems, is going to be a rather difficult one to standardize. I do not think the difficulties of atmospheric conditions are so very serious, generally speaking. Dense fog causes most of our trouble to the outside system. During other times we seem to get along without difficulty. I will relate some actual experiences concerning 3000-volt transmission, of sixty miles, carrying three substations, with power and lightning load, and sixty cycle synchronous rotary converters. The problem of the multigap arrester with the resistance in series with the gaps was a matter of years of study, and was finally given up because the series resistance sticks broke and the protection was lost. The next year we took up the multigap-arrester study without the resistance sticks in series. This arrester was very easy to adjust by changing the units to be shunted and changing the resistance of the shunt, too. We started with fourteen units, of 24 gaps each, shunting three units with 14 sticks, 250 ohms a piece. It was gradually dropped until we used ten units, dropping this to ten units below the multiplex connection between the fuses, shunting five units with seven, 250 ohms resistance sticks. We found by the tell-tale papers placed in the series gaps and shunt gaps (I mean by series the gaps in shunt), that when we had seven 250 ohm resistance sticks the current would seldom pass through the shunt resistance. We reduced them to five and then found that we got at least half of our discharges through the shunt, sometimes more. This arrester, adjusted in this way, has been successful. It takes light discharges without the slightest difficulty; it takes moderate discharges with but very little difficulty; it takes very severe discharges, at times, and these severe discharges cause the cylinder of the arrester to weld together, which of course puts the arrester out of service.

"Another thing that has been noticed is that the discharge is more frequently line to line than from line to ground. The 1906 record shows that we have taken in some storms twenty discharges without an interruption to service, our preliminary breakers being set at six seconds. We have taken seventeen discharges without interruption; the eighteenth discharge opening the breaker. We can cite case after case of storms in the surrounding country, but not directly on the system, where we will have intermittent discharges between the fuses to the extent of fifteen, or even as many as twenty-five, in the course of two or three hours, without the slightest indication of interruption. This is the best record we have been able to obtain with protective devices.

"The paper by Mr. Rushmore and Mr. Dubois speaks of choke coils. We have found them very effective and consider that they are a great protection to the high insulation, outside insulators. A 20-turn coil seems to answer our purpose fairly well.

"I do not wish to talk very much about Mr. Creighton's tests, although it was my pleasure to be at his laboratory at the time they were made. I can simply corroborate what he has said, that some 40 arcs were thrown to ground from one leg of his liquid arrester. The arresters just described, the record of which are given to you to show they are very sensitive, were in parallel with the liquid arrester. Not once was there any apparent discharge on any of the units of the multigap arrester. Dr. Perrine speaks of the length of the transmission line having a great deal to do with the matter of protection. That seems to be true. In our experience we found we have peaks developed between stations which do damage, but the arresters at the end of the line would help very much. We installed what we call our midway arrester, a multigap installation about ten to twelve miles from the power station, and immediately after this was put into service the constant static discharge on the power-station arresters and the substation arresters was cut down nearly half, and the constant static discharge at the midway arrester was equal, and is greater, than at the generating station or any of the substations. That seems to be a fairly good proof that arresters on the line are a good thing. For the benefit of other operating engineers I might state that this arrester equipment is very near the patrolman's house, so that it is easily controlled.

"The worst operating condition which we meet is a ground. We have more damage done to us when the fuse grounds than at any other time. I could not say that it is only with grounds that we destroy apparatus, but more apparatus is destroyed when we have grounds than at any other time. Mr. Creighton's liquid arrester, which was connected for the protection of grounds on the system, apparently solved the problem completely. The development of the liquid arrester brings out the fact that, at least for grounds, it may be necessary only to have arresters at the generating end of the system, or at least at the extreme ends, with no equipment in between."

"The significance of these three papers," said Mr. P. H. Thomas, "seems to be that Dr. Steinmetz and the other gentlemen, and their associates, have given a long and careful new study to the question of protection from lightning, and we have in the papers a statement of the conclusions which they have reached. The completeness of the presentation is particularly fortunate, and it would be interesting to note how nearly most engineers are coming into the same general line of protection. The multigap arrester with shunt resistance, leaving out of account the electrolytic arrester for the present, seems to be by all agreed to be the most promising direction in which to work. The differences now are comparatively small.

"Mr. Rushmore's paper was a careful, thoughtful presentation. He takes a broad view of the proposition, however, considering all the different questions, and I think he has taken pretty nearly the correct stand in each one. I am more inclined to agree with him in connection with the horn type of arrester than with Mr. Perrine. I think we are far enough advanced to protect our apparatus without the very annoying disturbances of the shutting down of the plant. The grounded wire is certainly some protection, but as Mr. Rushmore says, not complete protection. One of the difficulties, even if the wire is placed in, is that the discharge which strikes the line is more apt to come from the side. Coming from the side it approaches one of the side lines before it does the high line, and furthermore there is at all times one of these lines which is at a negative potential, with regard to the charge which is coming in the atmosphere; that is, it has a higher protection to receive the discharge than the ground wire itself. Taking these two things together, although the grounded wire will reduce the number of troubles, it can hardly be expected to completely eliminate them. It is often suggested that a grounded wire, if it be grounded frequently, will act promptly in reducing the severity of discharges, on account of the short-circuiting secondary action. It does not seem to me that it is probable that the effectiveness of this action will be at all considerable for this reason—to produce any corrective effect, the reaction of the induced circuit on the primary circuit must be considerable. Take an ordinary static transformer arrangement, which you see designed here, where the reaction of the secondary on the primary is practically perfect. To accomplish this result it is necessary to have an iron core and the closest relationship between the primary and secondary windings. In the constant current transformer, where there is provision to separate the windings, if the coils are close together, you have a perfect relationship between the primaries and secondaries, and you have a perfect reaction of the secondary on the primary.

"In his admirable discussion of the principles covering the discharge through a series of gaps, there was one thing Mr. Rushmore did not take into account, and that is the fact of the leakage of current over the surface of the insulator between the cylinders. This will tend to distort the conclusions numerically reached.

The question of power behind the tests is absolutely of importance in this sort of work, and inherently the higher voltage is more difficult to handle; and personally I should be very skeptical of the general non-arcing quality of this arrester without series resistance, and unless there are other data than what appear here. I should not suppose it would be safe to infer anything as to the general non-arcing quality. We find in one of the oscillographs that 200 amperes absolutely cuts the energy down from 2000 to 200 volts, showing a very limited capacity of power behind the discharge."

Mr. V. G. Converse said, in speaking of the horn arrester of which the Ontario Power Co. has a large equipment:

"I suppose that having had experience with a large equipment of horn-gap arresters I may be expected to take exception to the statement made in Mr. Rushmore's paper regarding this arrester, but on the contrary I in general agree with him. There are a few points, though detail ones, which can be overcome with the horn-gap arrester. Mr. Rushmore states: 'Where a fuse is used in series with a horn having no resistance it can, of course, take but the one stroke and after this the system is unprotected.' We have taken care of this undesirable feature by repeating fuses, and by the use of enclosed fuses, so that if one fuse blows a switch drops, connecting in a second fuse, a third fuse, a fourth fuse, etc. This type of enclosed fuse, as an arrester, very nearly meets Mr. Rushmore's requirement for the ideal arrester. It certainly does, in that it will put out the arc at the end of the half-cycle in which it starts. Mr. Rushmore further states: 'The real function of the horn arrester is its use to protect insulators along a transmission line, where the horns are so arranged that the current will jump to the horn before it will arc around the insulator. In this case the system would be disturbed either way. Where it is allowed to arc around the insulator, the latter would probably be destroyed and the time of disturbance of the system might be considerable—possibly until the insulator is replaced. With a horn protecting the insulator, the resulting short circuit, while very undesirable in itself, is less disastrous than in the former case, and may only necessitate starting up the synchronous apparatus again.'

"We have had very little trouble at our station. The Ontario Power Company, during the whole of the last season, had only one discharge from the generators at the generator station, but had a considerable number of discharges from the lines, breaking the insulators. These lightning arresters which have been described are essentially station arresters; they must be station arresters, because they must be so expensive we know that no company could afford to install them for a long transmission line. Our experience has been that lightning will hardly travel more than four or five tower lengths, before it will go to ground from the tower. We must not overlook the fact that the line protection for continuous operation is also important, nearly as important as the protection of the generating station apparatus."

Mr. William McClellen, New York, said: "It has been my privilege in the last few months to take part in the adjustment of the lightning protection of a substation which takes a current at 60,000 volts and delivers it at 11,000 volts to a trolley line. We were impressed with the fact that the choice of lightning protection depends very much on the amount of power you have back of it, and the voltage of the line you are trying to protect. For the 11,000 volt circuit we are intending to use a form of multigap arrester—perhaps some of these multigap arresters are better than others, but I see no reason why any of them should not answer the purpose fairly well. For the small amount of lightning which we have at this season of the year, I notice these gaps begin to show the effect which we know is the chief difficulty in the multigap arrester, and that is, that sooner or later, if the discharges are heavy and frequent, they will burn out. If you have sufficient power back of the arrester, so that you can wait for the horn arrester to open the circuit, you will not have a shut-down, but that applies only to the largest installations, because usually the gap and the resistance are set for the voltage of the line, and if the current through the resistance is too great for you to supply, in other words, if you have to wait for the horn to open, which takes sometimes a second—and if you will think of a second, it is a long time there, because some of the other resistances open in a very much shorter time, half a cycle—you will see a second is a very long time, and your circuit breakers are apt to trip the station."

Mr. Ray P. Jackson, State College, Pa., said in part: "In the type of electrolytic arrester which I have used, however, I do not consider it to be the counter e. m. f. that limits the power current. It seems to be a dielectric film, and that film is capable of puncture and capable of resealing when the voltage drops below a certain volume. It acts like a valve, with a spring behind it. When it is punctured, if the static excessive voltage exists long enough, there would be a very large power current flowing through, but of course the high voltage due to lightning or surges exists for a very short interval, so that the power current that follows is insignificant."

Mr. H. C. Wirt, in speaking of the electrolytic arrester, said: "The only disadvantage is, of course, the liquid. For some work, especially at lower voltages, 2000 volts, it would not be a convenient arrester to put around a city.

"I had hoped that these papers would have given more data regarding the operation of a shunt resistance type of arrester. I have personally followed some of the installations of these arresters, and I have some data in my pocket which I would like to submit regarding the operation of them. It is an installation at Joplin, Mo., 33,000 volt system. During two years with the series resistance type of arrester much trouble was being experienced, and we made one of the first installations of the shunt resistance arrester at that point. The operator states that he has secured almost perfect results from that type of arrester. The shunt resistance should be connected so that the arrester will break down at about 50 per cent. rise in voltage. If you put a resistance beyond that point, you are adjusting the circuit too near to the working voltage."

Dr. Steinmetz answered the objections against the use of the fuse by saying:

"If we omit the fuse with shunts and gaps, that means we have to leave the gaps in, and if the fuse blows we still leave that protection in the system, which would be the only protection, I think, if we desire to eliminate the fuse. The use of the fuse permits us to give a closer protection for most of the time and under most of the conditions, than would be permissible if we did not desire to use the fuse. This, therefore, is not analogous to the fuse in series with the horn arrester."

Reductions in Rates

THE Municipal Gas Company, of Albany, N. Y., has announced a reduction in the price of gas from $1.30 to $1.20 per thousand cubic feet, and the rates for electric current have been cut down from 15 to 12 cents per kilowatt-hours. These rates take effect on all sales made after the first of March. This action followed the passage in the State Senate of a bill reducing the price of gas in Albany to $1. It is expected this bill will pass the Assembly also.

On March 26th, the Narragansett Electric Lighting Company, of Providence, R. I., announced that commencing with the May meter readings the price of electric current for lighting would be reduced from 20 cents to 14 cents per kilowatt-hour. A sliding scale of discounts has also been established which will affect all bills for light running over $25, the discount increasing with the amount of the bill. This reduction affects the price of electric lighting throughout the entire State. This is the first change in price which has been made in seven or eight years by this company. The Narragansett Electric Lighting Company also controls the Bristol County Gas and Electric Company, of Bristol, which recently reduced the price of gas in Bristol, R. I.

The Allegheny County Light Company, of Pittsburgh, Pa., announced some months ago a reduction in the price of current for lighting from 16 to 12 cents per kilowatt-hour.

One of the results which naturally follows any reduction in the price of electricity is the increased demand for current. The conditions which make for this increase are twofold; from new customers added to the existing lines, as well as the use of more current by present customers. The new customers are a positive gain in bringing the district up to a higher per capita usage of current, provided they are located so that new mains are not required for their supply. A scattered business is not only more expensive to maintain, but involves extra investment in distributing lines. Owing to this consideration the wise manager pays considerable attention to getting old customers to extend their uses for current, as this is the least expensive form of new business.

Some Effective Business Schemes.

THE NORTH SHORE ELECTRIC COMPANY, which operates in the suburban district of Chicago, is one of the livest of central station properties, and a few of the business-getting wrinkles devised by its contract agent, Mr. John G. Learned, and presented by him in a paper for the Co-operative Electrical Development Association's 1906 prize are noteworthy.

It is absolutely necessary at times that the central station should maintain a wiring department, and also should encourage private local parties in the wiring business as the results are manifested. The more competition you have in the wiring business, the quicker your load will grow. If necessary, throw a few wiring jobs to the local man. It pays. Induce the man selling appliances to visit your territory. This also pays. If feasible, get all and any firms handling reliable electric appliances to solicit in your community. They are all working indirectly for the central station company.

We all know that the resident hesitates to have his home torn up, as he thinks it will be, and sometimes is, in order to install electric lighting wiring and fixtures. Again the expense prevents him from taking this step. Give the resident prospect a cost estimate for wiring his place. We find that by offering to put in the wiring and fixtures at cost on monthly installments we have secured a very large number of old houses, which if it were not for this proposition, would still be using antiquated methods of illumination. The new ones will, as a matter of course, take care of themselves. It is a very easy matter to induce a man building a new home to have it wired.

Experience has taught us that wiring for a porch light at cost has been the means of securing on our service a very large number of customers. Sixty customers were secured out of 275 people approached by a circular letter. This, you will admit, is a very large percentage. The cost of burning a porch light is nominal and rarely runs over 75 cents or $1 per month. At first sight you may think it does not pay to put in service for one lamp. It does. It is only a short time before the entire house or part of it is wired.

The next proposition for old residences is to wire for six outlets at a concessional price of one-half or the actual cost, the outlets mentioned to be placed as per direction of the consumer, with restrictions according to the conditions existing in your particular locality; six outlets will give the customer a chance to try the light and invariably result in putting on additional lights. This proposition was offered to about 600 old residents, out of which 53 responded and 23 were secured to the service. This is considered a small percentage.

The average man is always ready to accept something which apparently is free, therefore for a period of three months make a standing offer to allow $25 worth of current free to any resident who wires his home for a certain number of lights during that period, said free current to be used within a specified time. The results from this offer were very gratifying, in fact flattering, as about 40 old houses, which before making the offer were almost impossible to reach, readily came on the service.

The following very attractive proposition was offered to a selected list of about 200 residents who occupied their own homes:

"To the residents of your section who own their own homes, and who have considerable investment in them, we are making the following very attractive offer:

"We will bring our lines to your premises, install our service and at your direction wire for not to exceed six, single electric light outlets, entirely free of cost.

"We would suggest a light for the porch, controlled by a switch in the vestibule; one in the library for a reading lamp; one in that dark clothes closet will eliminate all possible danger of fire, and one in the furnace room controlled by a switch at the head of the stairs.

All we wish is that you agree to use electricity for burning the lamps for two years, and that your monthly bill be at least One Dollar.

"It is our intention to make but *one hundred* of these installations, and the first one hundred applications we receive will obtain this wiring free of cost. This involves an expenditure of a very considerable amount of money on our part, and if at any time you conclude to equip your premises throughout for the use of electric light, it will make a very material saving in the expense.

"The enclosed postal card with your name and address, mailed to us, will bring our representative, who will be pleased to give you full information on the subject."

Seventy responded to this letter, and as a result the central station was successful in securing 47 old residences, all of which are considered very good customers. Their bills average about $3.50 per month, this average taken for a period of eight months. The average cost of wiring each of the above houses mentioned was about $20.

The foregoing are a few of the schemes which have been used with success in obtaining old houses on the system. A new proposition will always bring in a few of the old residences.

Most towns have a few tenement and flat buildings. It is sometimes a task to obtain the lighting of these buildings. It is a good policy to have them wired at any cost, having the halls wired separately from the flats, this being done in the first place, the rest is easy. As a rule, tenants in flat building are very good customers, easy to secure and easier to hold. In order to permanently secure and hold the hall lighting, the central station shall allow the owner a special commission in the form of a discount on his hall lighting, this discount depending upon the number of customers in the building which use the central station service. As a result of this proposition the owner or agent of the building is instrumental in having a backward tenant use light. This proposition also applies to office buildings. Right here I will say that it is important for the district solicitor to win the heart of the janitor of the building, as he is of great value in securing flat customers. He is on the ground with the prospective customer at all times and a word from him goes a long way in convincing the prospect that he should use electric light.

The problem of securing store business we are ready and willing to admit is a very difficult one. Many schemes and methods have been tried. The writer suggests, however, that to start the wayward store customer using electric light by first getting him interested in lighting his windows.

To him window lighting is a matter of experiment. In order to show him that it is not an experiment with you but an absolute necessity, and that you have confidence in the fact that he will continue to use electric service, wire his windows free of charge. You may hesitate to do this. Don't. It is good business. It is not only an advertisement for the storekeeper, it is also the best advertisement the central station can obtain. The income is good, as a storekeeper, as a rule, is a long-hour user. Induce him to use the light in his windows when he has closed the store. In order to sell goods you must show them, and show them under the most favorable conditions. This may be done by using electric light. Teach him the why and how; how to light windows, and why, because it is his best advertisement. Impress upon him the necessity of showing his goods and show them as before mentioned, under the most favorable conditions. Space will not permit giving an illustration of the modern methods of window lighting. The writer considers trough reflector window lighting the most advantageous. The lighting of the interior of the store follows as a natural result. Each and every place requires special attention.

In those districts where you find that it will pay to maintain patrol service, install arc lamps on a flat-rate basis. Furnish the standard arc lamps, do the wiring, both for flat-rate service and also on meter basis, on meter basis with a special minimum monthly guaranteed. Experience has taught us that arc lamps are most satisfactory for space lighting and that a large amount of well-paying business has been secured by doing free wiring. Special attention should be given to the distribution and maintenance of arc lamps.

One branch of the electric lighting business too often neglected is signs. Do not hesitate pushing it. It means big revenue and is a good advertisement. Start out right. Hang a sign in front of your office, also one or two in another portion of the town to advertise your business. If you show the public that you believe in signs they will follow suit and you will find that the sign business will grow. Adopt a standard sign.

There are several companies that now make a specialty of furnishing central station companies signs at a reasonable price, which may be used time and time again. Signs furnished free to the customer have been means of securing a vast amount of business. By free the writer means that the signs are furnished, hung and connected without expense to the consumer, under a special contract whereby he agrees to use a certain amount of current each month. If patrol service is convenient, furnish the sign on patrol basis, if not, on meter basis.

The time has now arrived when the central station should be active in placing electric appliances among its current consuming devices. The electric flat iron seems to take best because it is an article which is in general use. There are several methods of placing them with the customer. Thirty days seems to give best satisfaction. Recently in a small community 37 irons were placed out on 30 days free trial and only two were returned. These small appliances are mostly used during the day. The income received from an ordinary No. 6 flat-iron is from $3 to $9 per year; therefore it seems advisable to sell appliances at as near cost as possible. The following is a circular letter sent to a few customers, return postals being enclosed.

"You use electricity for lighting because you know its many advantages, but you do not use it in all the comfortable ways you could or should. We have at least a dozen inexpensive appliances that should be in every household. They add to your comfort and convenience. You have really no idea how much until you have actually used them.

"I should like the privilege of sending to your home for your inspection any of our household electric appliances. First, I wish to send you a standard six-pound flat-iron on trial. Try it for thirty days and if it does not suit you return it. You are under no obligation to buy. This is the only way to show you the extreme convenience, simplicity, and economy of this up-to-date household necessity.

"Use the enclosed postal card, saying when I shall send you one. You will be under no obligation to do anything more than look at it, and should you think you do not wish to keep it (for a trial) we will return it without argument."

Another good scheme is to have a young lady call at the premises of the consumer and demonstrate the various electric appliances which you carry. Make it easy for the customer to secure the various articles.

In most towns there are a few drug stores. Advertising through the medium of a drug store seems to be most profitable, as every class will at one time or another call and make purchases at a drug store. Would suggest that an advertising cabinet, 30x50 inches, be placed in each drug store. Over the top of this cabinet place an incandescent lamp with a globe on it inscribed "Use Electric Light and Power," the cabinet to be provided with a glass door. In back of the glass door insert advertising matter periodically. The rent for space for this cabinet may be allowed in the form of a discount on the druggist's light bill. Said cabinet to contain pockets for advertising matter which is distributed by the central station, the only actual outlay of money in this advertising is the cost of the cabinet and the advertising matter you insert in it. A special agreement being made with the druggist to turn the light on the cabinet on and off.

The central station can readily afford to spend from 2 to 6 per cent. of its gross income for advertising purposes.

Annual Report of the New York State Commission of Gas and Electricity

THE corporations, municipalities and individuals furnishing gas or electricity for light, heat or power in the State and under the supervision of the Commission of Gas and Electricity number 426; the nominal capital engaged in the business is about $546,000,000; the gross income from operation approximately $75,000,000 per annum.

Coal, water, or mixed coal and water, gas is furnished by 51 of these plants; 162 furnish electricity; 51 supply both gas and electricity; 12 acetylene gas; 13 gasoline gas; and 41 natural gas. Of the municipalities, 3 are engaged in furnishing gas, acetylene or gasoline and 35 electricity. Of the individual plants, 40 supply electricity and 18 either acetylene, gasoline or natural gas. Included among the electric companies are 14 transmitting high-tension current.

APPLICATIONS.

During the year ending December 31, 1906, the Commission had before it for consideration seventy-four applications, upon all but three of which public hearings have been had.

The applications of seventeen companies for increase of stock and bonds were acted upon during the year. Sworn statements and testimony concerning the estimated cost of construction and equipment and examination in detail as to the values of the plants and franchises and of the indebtedness of the companies formed the basis of the determination. Consent was granted to the issue of stock to the amount of $5,348,000 out of a total of $7,333,000 applied for, a reduction of $1,985,000, or about 27 per cent. The issue of $910,000 bonds was approved out of a total $1,350,000 applied for, a reduction of 31 per cent. The combined stock and bond issues proposed amounted to $8,683,000. The amount granted was $6,258,000, the reduction $2,425,000, or about 24 per cent.

The following table shows the new corporations which made application for certificates of authority to transact business and the amount of stock or bonds applied for and allowed. A reduction of about 28 per cent. of the capitalization applied for was ordered after inquiry in each instance as to the purposes to which the proposed issues of stock and bonds were to be devoted. Consent was denied to issues of stock and bonds for remote or possible future development, further applications being allowable as such needs arose.

Municipalities desirous of engaging in the manufacture or supply of gas or electricity for other than municipal purposes are required by section 11 of the law to first obtain the consent of the Commission. The following is a list of such applications received and acted upon, with the amount of the proposed expenditures approved:

Village of Theresa	$23,000
Village of Union	15,000
Village of Lake Placid	45,000

COMPLAINTS AS TO PRICE.

No provision of the law has aroused such widespread public interest as that section conferring the power upon the Commission to fix the price of gas or electricity after a hearing. Complaints, as provided by section 15 of the law, may be made in writing by the mayor of a city, the trustees of a village, or the town board of a town, or by not less than one hundred customers of the company complained of, and after a hearing and investigation (section 17) the Commission may fix the maximum price which shall be charged, and may, upon its own initiative, order such improvements in the manufacture or supply of gas or in the manufacture, supply or transmission of electricity or in the methods employed as will in its judgment improve the service.

Name of Applicant.	Certificates of Authority. Issue of Stock.		Issue of Bonds.	
	Appliedfor.	Granted.	Appliedfor.	Granted.
Broadalbin Electric Light & Power Co.	$50,000	$7,500	$40,000	$40,000
Parish Lighting Co.	2,000	2,000	....	....
Paul Smith's Electric Light & Power Co.	100,000	75,000	....	....
Red Hook Light & Power Company	25,000	12,000	20,000	10,000
Andover Electric Power & Light Co	10,000	10,000	....	....
West Shore Gas Company	85,000	45,000	85,000	40,000
West Branch Light & Power Company	50,000	5,000	50,000	45,000
Citizens Lighting Co. of Oswego	75,000	75,000	....	....
Eureka Gas Company	2,000	2,000	5,000	5,000
Cherry Valley Gas Co.	10,000	6,000	....	....
Geneva-Seneca Elec. Co.	100,000	100,000	....	....
The Pavilion Nat. Gas. Co.	100,000	100,000	....	....
	$609,000	$439,500	$200,000	$140,000

In the matter of the complaint of the mayor of Syracuse against Syracuse Lighting Company, complaining of prices charged for both gas and electricity and of the illuminating power, purity and pressure of the gas and of the power and intensity of electric lighting, hearing was begun January 20, 1906, and after an investigation, in which the city and the company were represented by counsel, the Commission made an order fixing the maximum price of gas at 95 cents per thousand cubic feet, the maximum price of commercial electric lighting at 9 cents per kilowatt-hour the first year and 8 cents thereafter, and $68 for arc lamps for street lighting. The rates formerly charged were $1.20 per thousand for gas, with 20 cents discount for prompt payment; 12 cents per kilowatt-hour for commercial electric lights, with 2 cents discount; and $85.77½ for arc lamps. Eighteen candle-power was established for the illuminating power of the mixed gas furnished; a standard of purity was provided, and pressure was fixed at not less than that of a column of water one inch in height.

An appeal from the order of the Commission, made as a result of the investigation of the Syracuse Lighting Company, has been taken to the Appellate Division of the Supreme Court in and for the Fourth Department, and a stay of proceedings therein obtained.

The complaints of the mayor of Plattsburgh as to the price of gas supplied by the Plattsburgh Light, Heat and Power Company and of the price charged for electric street service furnished by the Lozier Light, Heat and Power Company were also adjusted after the Commission began its investigation. The terms of the agreement provided a price of $1.40, $1.50 and $1.80 per thousand cubic feet net for gas for lighting purposes and $1, $1.15 and $1.40 per thousand net for gas for heating, dependent upon the amount of gas consumed, as against a former charge of $2.50 per thousand gross for lighting, with 20 to 40 per cent. discount, and $1, $1.25 and $1.50 per thousand feet for heating. The price of electricity for commercial lighting purposes was reduced from a sliding scale of 20 cents to 6 cents per kilowatt-hour to a rate of 12 cents, 8 cents and 6 cents per kilowatt-hour.

The investigation begun upon the complaints against Municipal Gas Company of Albany and the Albany Electric Illuminating Company has been stayed by preliminary injunctions in proceedings instituted by the companies to obtain writs of prohibition.

VOLUNTARY REDUCTIONS OF PRICE.

During the past year voluntary reductions in the price of gas and electricity have been made by a large number of the lighting companies of the State, in many cases after conferences with the Commission. The following list shows the companies making such reductions, the territories benefited and the dates when the new rates became effective. The rates are hereinafter given in detail.

The gas companies in the following list have an aggregate annual output, to which the reduction in price applies, of approximately 840,000,000 cubic feet.

During the year the number of open arc lamps employed in street lighting by electric companies decreased from 9191 to 8605, and the number of enclosed arcs increased from 24,055 to 25,767. 50,101 incandescents are employed in street lighting.

Companies Reducing Price of Gas.

Name.	Territory.	Date
Rome Gas, Electric Light & Power Co	Rome	April 1, 1906
Cohoes Gas Light Co	Cohoes	May 1, 1906
The Poughkeepsie Light, Heat & Power Co	Poughkeepsie	May 1, 1906
Binghamton Gas Works	Binghamton	Jan. 1, 1906
Troy Gas Co	Troy and Waterford	June 1, 1906
Peekskill Lighting & R.R. Co	Peekskill	July 1, 1906
Lockport Gas & Electric Light Co	Lockport	Sept. 1, 1906
Kingston Gas & Electric Co	Kingston	Nov. 1, 1906
Fulton County Gas & Electric Co	Gloversville and Johnstown	Jan. 1, 1906
Peoples Gas & Electric Co	Oswego	Jan. 1, 1906
Suffolk Gas & Electric Light Co	Bay Shore, Islip and East Islip	March 1, 1906
Ithaca Gas Light Co	Ithaca	Sept. 1, 1906
Oneonta Light & Power Co	Oneonta	Jan. 1, 1907
Orange County Lighting Co	Middletown	Jan. 1, 1907

Companies Reducing Price of Electricity.

Name.	Territory.	Date.
Buffalo General Electric Co	Buffalo	
Commercial lighting		May 1, 1906
Public		June 1, 1906
Troy Gas Company	Troy.	
Commercial lighting		June 1, 1906
Public lighting		June 1, 1906
Beacon Electric Company	Troy.	
Public lighting		June 1, 1906
Lockport Gas & Elec. Lt. Co	Lockport.	
Commercial lighting		June 1, 1906
Public lighting		Sept. 8, 1906
Rochester Railway & Light Co	Rochester.	
Commercial lighting		June 1, 1906
Public lighting		July 1, 1907
Municipal Gas Company	Albany.	
Public lighting		June 21, 1906
Herkimer County Light & P. Co	Little Falls.	
Public lighting		Jan. 1, 1907
Cortland County Traction Co	Cortland.	
Commercial lighting		Oct. 1, 1906
Public lighting		Jan. 1, 1907
Rockland Light & Power Co	Nyack.	
Public lighting		April 1, 1906
Nassau Light & Power Co	Roslyn, Oyster Bay and various towns and villages in Nassau County	
Commercial lighting		Summer rates
Cohoes Gas Light Co	Cohoes.	
Power		June 1, 1906
Suffolk Gas & El. Lt. Co.	Bay Shore.	
Commercial lighting		March 1, 1906
Utica Gas & Electric Company	Utica.	
Public lighting		Jan. 1, 1907
Saranac Lake Light, Heat & Power Co	Saranac Lake.	
Commercial lighting		June 1, 1906
Montgomery Electric Light & Power Co	Canajoharie and Palatine.	
Commercial lighting		Sept. 1, 1906
Public lighting	Canajoharie.	April 15, 1907
Ellenville Electric Lt. Co	Ellenville.	
Commercial lighting		April 1, 1906
Empire State Power Co	Oneida.	
(Old contract with Madison County Gas & Electric Company.)		
Public lighting		Jan. 1, 1907
*Tonawanda Power Co	Tonawanda and North Tonawanda.	
Commercial lighting		Dec. 1, 1905
Oneonta Light & Power Co	Oneonta.	
Commercial lighting		Jan. 1, 1907
Schenectady Illuminating Co	Schenectady.	
Commercial lighting		Jan. 1, 1907
East Creek Electric Light & Power Company	St. Johnsville.	
Commercial ilghting		Aug. 1, 1906
*Keeseville Electric Company	Keeseville, Ausable Chasm, Port Kent and Peru.	
Commercial lighting		Nov. 1, 1905
Chatham Electric Light, Heat & Power Co	Chatham.	
Public lighting		Feb. 1, 1096
*Rome, Gas Electric Light & Power Co	Rome.	
Commercial lighting		Dec. 30, 1905
Ballston Spa Light & Power Co	Ballston Spa.	
Public lighting		Dec. 1, 1906
Yonkers Electric Light & Power Co	Yonkers.	
(Municipal buildings)		Jan. 1, 1906
Edison Electric Light & Power Co	Amsterdam.	
Commercial lighting		April 20, 1906
Public lighting		Jan. 1, 1907
Malone Light & Power Co	Malone.	
Commercial lighting		Jan. 1, 1906
Kingston Gas & Electric Co	Kingston.	
Commercial lighting		Jan. 1, 1906
Northern Westchester Lighting Company	Ossining and Croton.	
Commercial lighting		Feb. 1, 1906
Geneseo Gas Light Co	Genesco.	
Commercial lighting		July 1, 1906

*Not received in time to insert in first report.

The Buffalo General Electric Company May 1st reduced the price to be charged for electricity for incandescent lighting from a sliding scale of 12 to 4 cents, to a sliding scale of 9 to 4 cents per kilowatt-hour. Reduction was also made in the prices to be charged for series arc lighting, and beginning June 1, 1906, the rate for public arc lighting will be $56 per annum for not less than 2833 lights, but any new lamp supplied by underground wires to be at the rate of $75 per annum.

The Troy Gas Company has made a new contract with the city for public lighting for five years from June 1, 1906, to supply about 460 arc lights at 26 cents per night, or $94.90 per annum as against 32¾ cents per night previously, and to furnish electricity to the city building at 10 cents per kilowatt-hour.

The city of Troy entered into a new contract June 1st with the Beacon Electric Company to supply 178 or more nominal 2000-candle-power arc lamps for street lighting at 26 cents per lamp per night as against 32¾ cents per lamp per night under the old contract. The Beacon Electric Company supplies the three northern wards of the city, formerly known as the village of Lansingburgh. The contract is for a period of five years.

The Lockport Gas and Electric Light Company announced June 18th that from June 1st a reduction of 25 per cent. from the rate in force would be given on all current sold by meter providing monthly bills are paid by the 15th of the following month. Rates heretofore have been as follows:

For electric lighting	1st	50 kilowatts	10 cents.
	next	50 kilowatts	9 cents.
	next	100 kilowatts	8 cents.
	next	200 kilowatts	7 cents.
	over	400 kilowatts	6 cents.

Rates for electric power, service charge of $1 per k. w. for average of month, or 75 cents per horse-power and from .64 cents to 2 cents per k. w. additional charge by meter, dependent on number of kilowatt-hours used, or about $22.63 per horse-power per annum.

The Rochester Railway and Light Company adopted a new schedule for electric lighting in residences June 1, 1906, to such customers as executed and returned contracts therefor, under the new rate, on or before June 15th. The price of residence lighting was reduced from 14 cents per kilowatt-hour to 10 cents, with a discount of 10 per cent. if paid on or before the 12th day of the month following, with a minimum charge as follows:

For 15 16-candle-power lamps or less	$1.00
Over 50 and not exceeding 100 lights	2.00
100 lights and over	3.00

A new contract for public arc lighting was entered into February 5, 1906, between the city of Albany and the Municipal Gas Company for a period of five years, beginning June 21st, at 27 cents per day, or $98.55 per year, including repairs, cleaning and replacing broken globes. Under the old contract the city did the repairing, cleaning, etc. To the old price of $116.80 per year $5 was added for repairs and 90 cents for broken globes, making the net cost $122.70 per lamp, as against $98.55 under the new rate. New lights were formerly installed for $153.80, including the cost of the new lamp, the post and the lighting for one year, the cost under the new rate being $135.55.

The city of Lockport has entered into a new contract with the Lockport Gas and Electric Light Company to supply arc lights at $55 per lamp for an arc light of 1200 nominal candle-power, burning 4000 hours approximately, to go into effect September 8, 1906.

Beginning January 1, 1907, the Herkimer County Light and Power Company is to furnish to the city of Little Falls series, alternating, enclosed arc lamps of 7½ amperes or 540 watts at the lamp at $35 for all night service under a five-year contract.

The Cortland County Traction Company has recently made a five year contract with the city of Cortland for 110 arc lights for 24 cents per light on an all night schedule, to go into effect January 1, 1907. The old schedule was moonlight 1 A. M., running about 20 nights a month, for which the company received 28½ cents per night per light.

The maximum rate to private consumers was reduced October 1st from 12 to 11 cents per k.w.

The Rockland Light and Power Company, April 1, 1906, reduced the price of street arcs in Nyack from $105 to $88 per year in consideration of the increased expenditure for lighting per mile of street circuit.

The Nassau Light and Power Company, supplying Roslyn, Oyster Bay and various towns and villages in Nassau County, reduced the price of 20 cents to summer customers to 15 cents with deposit for one month's light bill.

The Cohoes Gas Light Company June 1st reduced the price of power to consumers having accounts of over $20 per month by increasing the rate of discount from 50 per cent. to 66 2/3 per cent. on the regular charge of 15 cents per k.w.

From March 1, 1906, the Suffolk Gas and Electric Light Company, of Bay Shore, established a discount of 10 per cent. from its regular rate of 20 cents per k.w. for cash if paid within ten days.

The Troy Gas Company reduced its maximum rate June 1, 1906, from 16 cents to 15 cents per k.w.

The Utica Gas and Electric Company on October 5, 1906, extended the existing contract for lighting the streets of Utica with arc lights for five years from January 1, 1907, at $56 per arc lamp as against $109.50, the price stipulated in the present contract. The company further stipulated that if at any time during the extension of the contract the stipulated rate was reduced by the Commission that the company would abide by it. This action was taken pursuant to the recommendations of an exhaustive report made by members of the common council, reciting the action of the Commission in the Syracuse Lighting Company case, and giving the result of investigations at Syracuse, Rochester, Buffalo and Niagara Falls. Estimated saving for full term of contract, $206,242.50.

The Saranac Lake Light, Heat and Power Company, June 1, 1906, made a new rate of 15 cents per kilowatt-hour for an equivalent of 50 hours burning per month for each lamp installed, with 6 cents per kilowatt-hour for the excess. The former rate was 15 cents for an equivalent of 70 hours and 6 cents for the excess.

The Montgomery Electric Light and Power Company, lighting the villages of Canajoharie and Palatine, reduced the price of electric current to small consumers from 12 cents to 10 cents per kilowatt-hour September 1, 1906.

The Ellenville Electric Light Company reduced its rate April 1, 1906, from 17½ cents per kilowatt-hour to 15 cents, with a rate to factories of 9 cents per kilowatt-hour. All bills over $5 are entitled to a discount as follows: $5, 5 per cent.; $10, 10 per cent., etc.

The Rochester Railway and Light Company entered into a new contract, September 15, 1906, for five years for the care, maintenance and lighting of the city's electric street lamps from July 1, 1907, to July 1, 1912. Under the prior contract the price per night for 2712 single arc lamps was 21½ cents or about $78.50 per year. There were also in use 495 lights hung in pairs for which the company was receiving 18¼ cents each per night, or $66.61 per year, making the total number of arc lights paid for by the city 3209. It was estimated that the average number of lamps of the different classes for the five-year period would be as follows:

Underground circuit in pairs on iron poles	500
Underground circuit single lamps on iron poles	500
Overhead circuit single lamps	2600

200 32-candle-power incandescents were provided for in the new contract as against none in the old. The prices submitted by the company were as follows:

Arc lamps connected with underground circuit located singly	$68.00
Arc lamps connected with underground circuit located in pairs	62.96
Arc lamps connected with overhead wires	57.95

This amounted to a saving of $60,505 per year, or $302,525 for the five-year period.

The city of Oneida has made a new contract with the Empire State Power Company for public arc lighting at $37.50 per arc light. Under the old contract with the Madison County Gas and Electric Company the price was $66 for one o'clock service. The new service is for all night to begin January 1, 1907.

The Tonawanda Power Company, lighting Tonawanda and North Tonawanda, reduced the price for commercial lighting, December 1, 1905, as follows:

From, resident incandescent lighting 15 cents per k.w. with 20 per cent. discount, and 12 cents per k.w. for commercial incandescent lighting, discount 10 per cent.

To, 10 cents per k.w. for resident and commercial incandescent lighting, with discount of 10 per cent.

Or, a sliding scale at the option of the customer of 12 cents to 6 cents per k.w. with 10 per cent. discount.

The Oneonta Light and Power Company will, January 1, 1907, reduce the price of electricity from 15 to 10 cents per k.w., minimum charge $1 per month.

The East Creek Electric Light and Power Company, supplying electric light for the village of St. Johnsville, reduced the price of electric current for lighting, August 1, 1906, from 10 cents to 8 cents per kilowatt-hour.

Keeseville Electric Company, November 1, 1905, reduced the price of electric current to customers consuming more than 50,000 watts per month to one-half the base rate of 12½ and 10 cents per k.w.

The Chatham Electric Light, Heat and Power Company entered into a new contract with the village of Chatham, which went into effect February 1, 1906, by which one 4.25-ampere arc lamp at $70 and six 6-ampere lamps at $85 each, replaced one 3-ampere lamp at $54 and six 4.25-ampere lamps at $75 each. 115 25-candle-power incandescents under the new contract were furnished at $1.30 per month instead of $1.08 1/3; 16 16-candle-power lights for village purposes were furnished free.

About December 30, 1905, the Rome Gas, Electric Light and Power Company reduced the price of power from a sliding rate with a maximum of 8 cents per kilowatt-hour and minimum of 3 1/5 cents, to the following:

0 to 400 h. p. hrs.	.0596	per h. p. hr.
400 to 420 h. p. hrs.	.0586	per h. p. hr.
420 to 440 h. p. hrs.	.0575	per h. p. hr.
1,000 to 2,000 h. p. hrs.	.02565	per h. p. hr.
2,000 to 3,000 h. p. hrs.	.024125	per h. p. hr.
3,000 to 4,000 h. p. hrs.	.0225	per h. p. hr.
17,000 to 18,000 h. p. hrs.	.013125	per h. p. hr.
18,000 to 19,000 h. p. hrs.	.013125	per h. p. hr.
19,000 to 20,000 h. p. hrs.	.0125	per h. p. hr.

With a discount of 5 per cent. if paid before the 10th of the month.

A new contract for the lighting of Ballston Spa by the Ballston Spa Light and Power Company went into effect December 1, 1906. 218 25-candle-power incandescent lamps are furnished at $15 from one-half hour after sunset to one hour before sunrise. Under the old contract the rate was as follows: For 54 lamps from one-half hour after sunset until one hour before sunrise, $22 per annum, and 164 lamps until 3 A. M., $18 per annum.

The Yonkers Electric Light and Power Company, January 1, 1906, reduced the price of city lighting to the municipal buildings of the city of Yonkers from 15 cents per kilowatt-hour for the first two hours average daily use of the total connected capacity, 10 cents for the 3d and 4th hours and 5 cents for excess average daily use, to the flat rate of 10 cents per kilowatt-hour. This rate was not applicable, however, to commercial lighting.

The Montgomery Electric Light and Power Company renewed a contract which expires April 15, 1907, for street arc lighting in Canajoharie at $66.67 per annum per arc lamp, for five years from that date at $50 per arc lamp.

The Edison Electric Light and Power Company of Amsterdam reduced the price of commercial lighting, April 20, 1906, from a sliding scale for lighting varying from 12 cents per kilowatt-hour to 6 cents per kilowatt-hour according to consumption, to a rate of 5 cents per kilowatt-hour less 10 per cent. discount, with a rate of 3 1/3 cents per kilowatt-hour for large installations consuming in excess of 1000 k.ws. per month. The city of Amsterdam has entered into a new contract with the Edison Electric Light and Power Company for lighting the public streets at the rate of $39.50 per lamp per year where the lamp is served from aerial lines, and $51 per lamp per year where the lamp is served by the underground system. Under the former contract the rate was $68.99 per lamp per year for 2000-candle-power lamps on an all night schedule.

Beginning with January, 1906, the Malone Light and Power Company reduced the rate of 12 cents per kilowatt-hour for bills of less than 25 kilowatt-hours per month, to 10 cents, the rate previously charged on a monthly consumption exceeding that amount, and the meter rent of 20 cents per month on bills of less than $3 was also abolished.

The Kingston Gas and Electric Company, January 1, 1906, reduced the rate for metered power service from 8 cents per k.w. with a discount of 10 to 25 per cent., to 7 cents per kilowatt-hour on a consumption not exceeding 50 kilowatt-hours per month and from

50 to 200 k. w. hrs. per mo.	5.6 cents per k. w. hr.
200 to 1000 k. w. hrs. per mo.	4.9 cents per k. w. hr.
1000 to 2000 k. w. hrs. per mo.	4.2 cents per k. w. hr.
2000 k. w. hrs. upward per mo.	3.5 cents per k. w. hr.

with a discount of 10 per cent. on all bills exceeding 50 kilowatt-hours per month.

The Northern Westchester Lighting Company, after February 1, 1906, allowed to customers in Ossining and Croton discounts of 10 to 20 per cent. as follows:

10 per cent. on bills under $10.
15 per cent. on bills under $15.
20 per cent. on bills over $15.

Prior to that time no discount had been allowed on the rate of 20 cents per kilowatt-hour.

Geneseo Gas Light Company reduced the rate July 1, 1906, from 1 cent per ampere-hour (equivalent to 20 cents per kilowatt-hour) to 12 cents per kilowatt-hour for incandescent lighting.

Beginning January 1, 1907, the Schenectady Illuminating Company established the following rates:

1st	25 kilowatt-hours	12 cents.
Next	50 kilowatt-hours	10 cents
Next	100 kilowatt-hours	8 cents
The balance at		7 cents

with a cash discount of 16 2/3 per cent.

A new power rate was also established, namely: a sliding scale from 7 cents to 3½ cents per kilowatt-hour, depending upon consumption per horse-power of installation. A cash discount of 10 per cent. is also allowed.

The minimum charges on lighting installations will remain as heretofore. The minimum charges under the power rate will be $1 per month each, installations of 1 and 2 horse-power capacity, on installations above 2 horse-power the minimum charge will be 50 cents per horse-power per month.

The former rates were 15 cents per kilowatt-hour, with cash discounts of 10 to 50 per cent., according to consumption, and a special rate of 10 cents per kilowatt-hour with discounts of 10 to 50 per cent. on a contract of guaranteed consumption.

Street Lighting in Denver

APPRECIATING the fact that attractively lighted streets are one of the potent factors in drawing attention to a city, Denver, some time since, placed a "Welcome" arch at the entrance to the union station which has attracted a great deal of attention. Another step has now been taken in the effort toward securing a "great white way" by putting in a new lighting system on Sixteenth Street. The new lamps are placed on ornamental iron poles, which are also arranged to carry the trolley span wires.

ORNAMENTAL LAMP POST.

The Sixteenth Street lighting scheme is part of the plan of Mayor Speer to make Denver a city beautiful by night. In this effort he has made a close study of the ways and means to attain this result, in which he has been effectually aided by a municipal art commission composed of leading citizens. The Sixteenth Street lights have become so popular that there is considerable clamor for the extension of the system to other business streets. Plans are now under way to extend the system to two other streets.

The lamps used are supplied with alternating current. Ninety-eight iron poles were used on Sixteenth Street and the entire cost of the system was $16,000.

Cooking by Electricity

THE Woman's Club, of Dubuque, Ia., with the co-operation of the Union Electric Company has arranged for Mrs. F. V. Sanborn, a well-known writer on domestic science, to deliver a series of fifteen lectures on household economics and cooking by electricity. The first demonstration and lecture was given on April 1st, and the series was announced by engraved invitations sent to the members of the club. The arrangements for this course were largely due to Mr. L. D. Mathes, the general manager of the Union Electric Company. Mr. Mathes has been very active in promoting the sale of current and expects to find this a most effective method of interesting people in the many possible uses of electricity in household.

The Lazier Gas Engine

THE Lazier Gas Engine Company, of Buffalo, New York, is one of the new arrivals in the gas-engine field. This company, however, will have the benefit of the long experience of Mr. Arthur A. Lazier in this line of work, and have associated with him a staff of experts.

The new machine is already on the market, and owing to its simple design is well worth investigation by those contemplating the use of gas engines. In getting up these machines the designer kept in mind the desirability of accessibility and simplicity of parts; and arranged the mechanism so that it is not necessary to dismantle the machine for simple repairs. The accompanying cuts show a longitudinal and cross section of the engine and give a clear idea of its construction.

The National Electric Light Association Convention

THE convention this year will be held at Washington, D. C., June 4th to 7th, and quarters have been secured at the New Willard Hotel. The exhibition hall will be on the same floor with the hall in which the meetings are to be held. This arrangement promises to be very satisfactory and convenient. The large ballroom of the New Willard has 10,000 square feet of floor area, and this has been laid out for seventy-eight booths. A gallery at the north end and a balcony on the east side of the exhibition hall will give an opportunity to observe the exhibits from above.

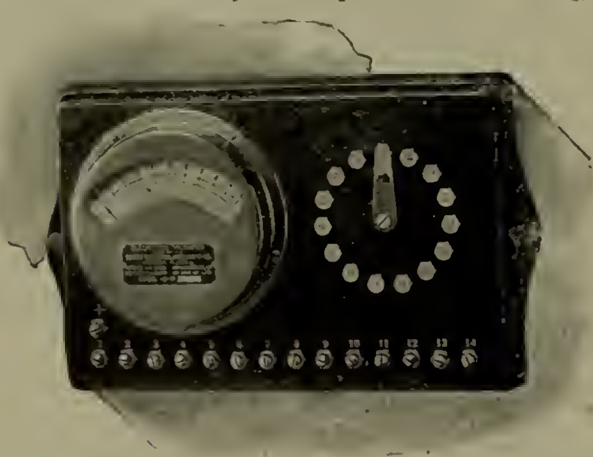
Mr. Walter Neumuller, Vice-Chairman of the Exhibition Committee, 55 Duane Street, New York, has charge of the space arrangements.

Rechargable Dry Cells

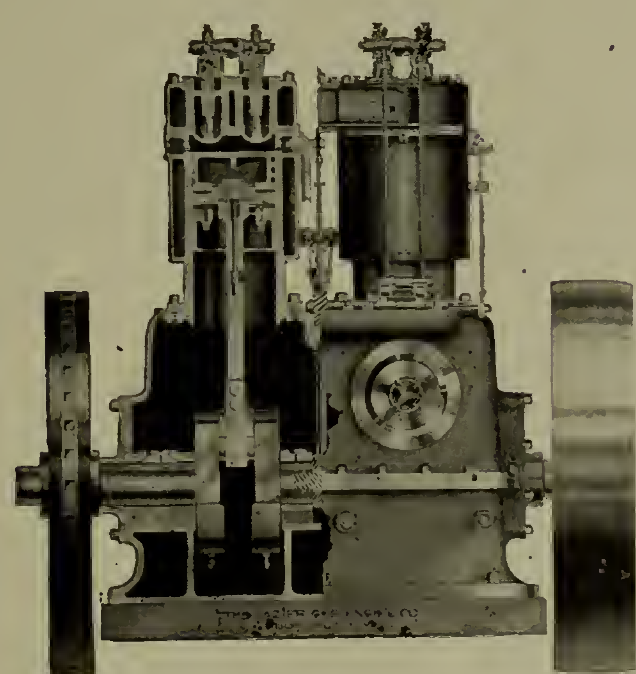
THE Railway Safety Service Company, Besse Building, Springfield, Mass., is placing upon the market a rechargable dry cell battery which the manufacturers state is the equal to the best dry cells that are manufactured. The cells can be charged in two minutes, while enroute, by a simple recharging apparatus which can be carried in the tool box of any motor car. The battery can be recharged as many as twelve times and after each charge is maintained by the makers to be equally as efficient and as long lived as any dry cell battery of commercial merit and utility on the market when fresh from the manufacturer.

Electro-Platers Voltmeter

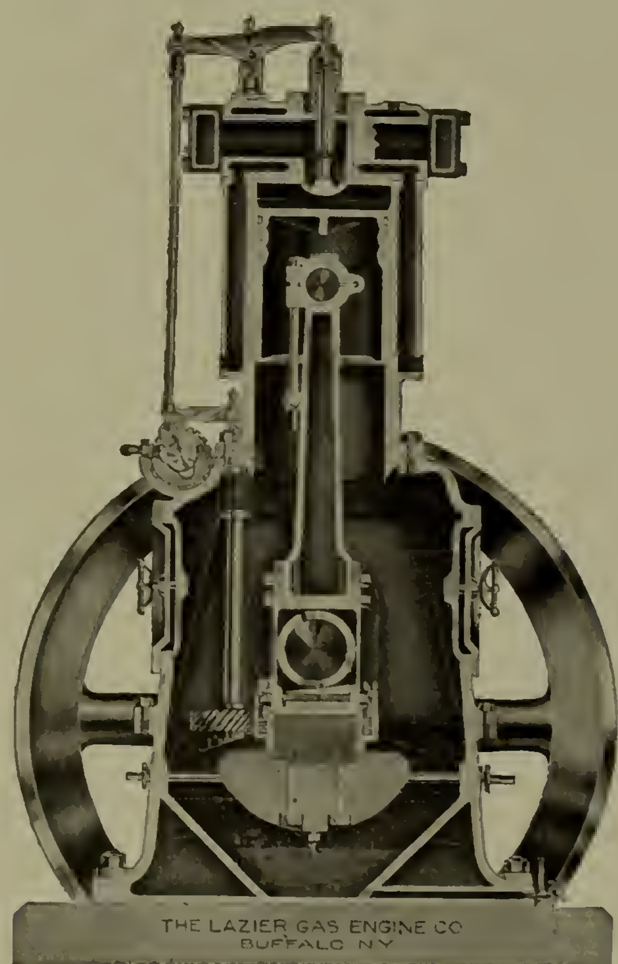
THE Weston Electrical Instrument Company, of Newark, N. J., have placed on the market a volt meter designed especially to meet the requirements of electroplaters. This instrument is arranged for connection to from one to fourteen tanks, by independent binding posts. The use of this instrument by electroplaters is calculated to reduce the work from a guess-work basis to uniform results, preventing "burnt" work and thin deposits with their attendant troubles.



ELECTRO-PLATERS VOLTMETER.



LONGITUDINAL SECTION, LAZIER GAS ENGINE.



CROSS SECTION, LAZIER GAS ENGINE.

New Type Direct-Current Generator and Balancer Sets

A LINE of direct-current generators ranging in size from 1½ to 17½ KW. has been developed by the General Electric Company. These machines are designated as Type CQ and embody the cylindrical construction which has distinguished the CQ and CG motors. They are especially applicable as exciters for alternators or to supply direct current for power plant purposes, where a small size of belt-driven generator is desired. These machines are compact and the bearing heads are so designed that the machines can be installed on the floor, wall or ceiling, where the space is available. Owing to their design the magnetic circuits are short and the efficiency, it is stated, is high for such small machines.

The field and armature coils are form wound and removable, and are treated with an insulating compound which makes them moisture proof. The armature has toothed slots and large radiating surface. Non-shifting carbon brushes are used and the windings are designed to insure sparkless running with all load variations. The machines are compound-wound for 125 and 250 volt circuits.

A balancer set has also been designed for use on three wire circuits consisting of two CQ machines mounted on the same base. This set has forced ventilation for the armatures and an intermediate bearing of the ring-oiling type, similar to those on the regular machines. Owing to its small floor space requirements this set is very convenient.

BALANCER SET.

GENERATOR.

The Electric Supply for the Jamestown Exposition

THE electric current for the approaching exposition at Jamestown is to be generated outside the exposition grounds. In this case, however, there is no Niagara Falls available, as was the case at Buffalo, for the Pan-American Fair; hence the steam turbine plant of the Norfolk Railway and Light Company, located about seven miles from the Exposition grounds, will be utilized. This will, therefore, be the first fair for which the power will be generated entirely by steam turbines.

The power will be generated at the Jamestown plant of the company by General Electric turbo-generators of the Curtis type, and transmitted to a substation in Machinery Hall, at the Exposition on a special line. The equipment of this substation will consist of transformers, rotary converters and motor generators designed to supply current to suit a wide variety of purposes.

Legal

BURKE PATENT VOID FOR ANTICIPATION.

In this action the Burke patent, No. 631,518, for an improvement in frames for electric motors or generators, consisting of a frame or cradle in which the armature is mounted, with bearings for the ends of the shaft to maintain it in perfect alignment, was held to be void as anticipated in motors for operating elevators previously in use in which similar cradles were used; and the Bliss patent, No. 669,574, for a frame for electric motors was also declared void as anticipated by a similar device. New England Motor Co. v. B. F. Sturtevant Co., Circuit Court of Appeals, New York, 150 Federal Reporter, 131.

INVALIDITY OF THE VAN DEPOELE REISSUE PATENT, NO. 11,872 (ORIGINAL NO. 495,443) FOR A TRAVELING CONTACT FOR ELECTRIC RAILWAYS.

The twenty-second decision in connection with this patent has been handed down by the Federal Circuit Court of New Jersey, which has again declared the patent void because of the delay of more than seven years after the issue of the original patent. This application for reissue was made three years after the patent had been declared invalid by a circuit court of appeals, during which time suits were being prosecuted in other circuits. The patent was therefore declared void, agreeing with the view taken by the Circuit Court of Appeals for the Sixth District in the case of Milloy Electric Co. v. Thomson-Houston Electric Co., 148 Federal Reporter, 843. Thomson-Houston Electric Co. v. Sterling-Meaker Co., 150 Federal Reporter, 589. (Febr'y 2, 1907).

UNION ELECTRIC LIGHT & POWER CO. V. SURGICAL SUPPLY CO. ST. LOUIS COURT OF APPEALS, MISSOURI, 99 S. W. REP. 804.

This was an action for a balance of $133.08, on account of electric power furnished to defendant by the plaintiff under a written contract. It appeared that one of the plaintiff's bookkeepers had by mistake described in his register book the meter installed in the defendant's premises as "½ constant," when in fact the meter was "1" or "o constant," and consequently the monthly bills rendered to defendant for fourteen months were for only one-half of the actual electric power furnished. The monthly bills were promptly paid as rendered. The mistake in the description of the meter as recorded by the bookkeeper in the plaintiff's register book—a book in which were recorded the meter slips turned into the office by the plaintiff's meter readers—was not discovered until after the expiration of the contract period, when the meter was taken out and returned to plaintiff's meter department. In the court below judgment was given for the plaintiff, from which the defendant appealed. On appeal the court held that, as the defendant had not, in ignorance of the mistake, so changed its position by doing anything in reference to the subject-matter of the contract that to correct the mistake would result in injury to him, and as the mistake resulted in injury to the plaintiff and to an unearned profit to the defendant, the plaintiff was entitled to recover the balance sued for, and the judgment was affirmed.

PERSONAL INJURIES RECEIVED OWING TO DEFECTIVE WIRING IN A BUILDING—NON-COMPLIANCE WITH CITY ORDINANCE.

In a recent Massachusetts case a verdict in favor of the plaintiff in an action against the Lowell Electric Light Company, who furnished the plaintiff with electricity, for injuries received as a result of an extension of the plaintiff's wiring was set aside. The circumstances were as follows: The plaintiff occupied an apothecary store in Lowell, with a cellar underneath. Defendant is a corporation furnishing electricity for light, heat and power in the city of Lowell. The plaintiff's inside wiring was installed by an electrical contractor, and all the wires and other electrical apparatus inside of the store, except the fuses, fuse box and meter, were his property. Defendants brought the electricity to the wall of his store and there delivered it through a meter onto the wires within the store. The plaintiff employed an electrical contractor to make an extension of his wiring in the cellar of his store, but he did not notify the defendant of his intention to do so, nor did he obtain a permit from the city's inspector of wires to make the extension, nor comply with the rules and regulations of the National Board of Fire Underwriters, as required by the Lowell city ordinance of July 26, 1899, Sections 9, 10, 11. After the extension was made, the plaintiff went to his cellar, and before going down turned on the switch which lighted the cellar lamp. He took hold of the flexible stranded covered cord forming the extension of the wiring, to which was attached a lamp socket for an incandescent light, in such a manner that a part of the cord and a part of the lamp socket were in his hand, and in taking the light from the support he received a shock of electricity which threw him down, rendered him insensible and inflicted severe injuries upon him. His hand was subsequently found to be severely burned and several fingers were amputated. The court held that the conduct of the plaintiff in disregarding the requirements of the ordinance was the cause of the injury and that he was not entitled to recover against the corporation. Evidence of the inspector of wires to the effect that where wires were already installed and there was simply an extension made, it was not his practice to require an application to be made and a written permit obtained before the current was turned on, was held to be inadmissible. Brunelle v. Lowell Electric Light Corp., Supreme Court of Massachusetts, 80 Northeastern Reporter, 466.

LIABILITY FOR PERSONAL INJURIES NEGLIGENCE OF ELECTRIC COMPANY.

While a boy of fifteen years of age was climbing on a pier of a public bridge he placed his hands upon a live wire strung a short distance from the pier and 30 feet above the ground, fell to the ground and was injured. In an action for damages for personal injuries it was held that the electric company owning the wire could not reasonably be expected to anticipate such an injury; that there was no attraction connected with the property of the company which was calculated to allure the boy to the place where the injury was sustained, and that the boy was a trespasser, not being in a place where the public could rightfully go for pleasure or business, and having no duty in connection with the bridge. The rule of law imposing upon persons handling or manufacturing dangerous elements and substances the duty of exercising the highest degree of care to protect the public from danger in all places where they might rightfully be did not impose any liability upon the company under the circumstances stated. Graves v. Washington Water Power Co., Washington, 87 Pacific Reporter, 956.

Obituary

Prof. E. Hospitalier, who is well known in electrical circles, died recently in Paris. Prof. Hospitalier was born in 1852. He was educated at the Ecole des Arts et Metiers, Aix and l'Ecole Centrale, Paris, graduating from this latter institution with the degree of mechanical engineer. In 1879 he became the editor of La Lumière Electrique, and in 1883 he was made editor of L'Electricien, with which paper he remained until 1891, when he founded L'Industrie Electrique, of which he remained editor until his death. In 1882 he was appointed professor of electrical engineering of L'Ecole de Physique et de Chemie Industrielle, of Paris, which chair he occupied at the time of his death.

Prof. Hospetalier was one of the founder members of the Société Internationale des Electriciennes, and has at various times held every office within the gift of the society. He is probably best known through his services on the juries of award of a number of expositions and through his books. His best-known work is the "Formulaire Practique de l'Ectricien," which first appeared in 1883, and which has been revised annually.

Prof. Hospitalier was the inventor of the ondugraph for investigating the wave forms of alternating currents and the monograph, which is used for indicating gas engines.

In 1888 Prof. Hospitalier was appointed an officer of the University of France, and in 1900 he was decorated as a chevalier of the Legion of Honor. In 1899 he was appointed a commander of the Order of the Crown of Italy.

Gen. Eugene Griffin, first vice-president of the General Electric Company and manager of the sales department, was stricken with apoplexy while dining at the Mohawk Club in Schenectady and died two hours later, without having regained consciousness, at one o'clock on the morning of April 11th.

He, together with his wife and daughter, came up to Schenectady to attend an amateur minstrel show, given by the Song and Jest Club, an organization of the younger engineers of the General Electric Company. Following the performance, in which his son took part, Gen. Griffin gave an informal dinner to the performers at the Mohawk Club. While at the table he suddenly collapsed.

Gen. Griffin was born at Ellsworth, Me., Oct. 13, 1855. He entered the Military Academy at West Point in 1871, and was graduated in 1875. He resigned as chaplain of the Regular

Army in 1889, organized and commanded the First Regiment United States Volunteer Engineers during the Spanish-American War and was with Gen. Miles in the Porto Rican campaign. He has been first vice-president and sales manager of the General Electric Company from its organization. He was a member of the Board of Governors of the Engineers' Club and was actively interested in the work of that organization. He was also a member of the Building Fund Committee of the Engineering Societies Building.

Book Reviews

Electro-Chemistry

By Max Le Blanc, Professor in the University of Leipzig; translated by Willis R. Whitney, Ph.D., and John W. Brown, Ph.D.; published by The Macmillan Company, New York. Cloth; 6 x 9 in.; 338 pages; 51 cents. Price, $2.60 net.

THIS is a translation of the fourth German edition of Professor Le Blanc's text-book, with some additions made by the translators, which have been placed in brackets in order to distinguish them from the original text.

The original basis of this book was Professor Le Blanc's lectures, the first edition being issued in 1895. Since then the work has been greatly added to and enlarged. The effort has been made to include in this book all of the essentials of the science and at the same time to keep the work within reasonable size. This effort of the author has been well carried out.

In this book a consistent form of notation has been adopted and a nomenclature conforming with other standard works on electricity and chemistry. It is hardly necessary to enlarge on the convenience and desirability of such a step. In many works their usefulness is greatly impaired by reason of the same symbol being utilized in a variety of ways. Hence one is never certain as to its meaning; and the continuity of thought essential to study is broken.

This work is essentially a text-book on electro-chemistry which cannot fail to be a valuable addition to the library of all interested in this subject. A number of footnotes refer to the literature of electro-chemistry.

Long Distance Electric Power Transmission

By Rollin W. Hutchinson, Jr., Association A. I. E. E., published by D. Van Nostrand Co, New York. Cloth; 5½x8 in.; 345 pages; 136 illustrations. Price, $3 net.

While intended as a book of reference for students and engineers, this work will be found of service by those who desire to obtain information on the subject. The author does not claim to present any new methods, but has gathered in his work an interesting *résumé* of current methods of construction, and refers the deeper student to the proper authorities for detail treatment, a very useful tabulation of the bibliography of the subject covered being found at the end of each chapter. This is one of the most valuable features noted. Owing to the broad field covered, the treatment of each subject is concise and presupposes a knowledge of those elementary portions of the subject, which are too often repeated in many books without adding to their reference value.

On Municipal and National Trading

By Lord Avebury P. C., published by Macmillian Company, New York and London. Buckram; 178 pages; $1 net.

WHILE this book deals exclusively with English conditions, it is an extremely valuable contribution to the literature on municipal and national ownership, and is a thorough and fair-minded exposition of the conditions which legitimately follow the extensive adoption of socialistic principles. England has had an extended and disastrous experience along these lines, owing to the fact that municipal and national trading has been gone into on a wider scale there than elsewhere, and the results of amateur and impersonal managerial responsibility are now reflected in increased taxation and heavy debts of the local authorities. In England and Wales the rate of taxation per head has increased 83 per cent. in twenty-four years, the average debt per head has risen 118 per cent., and the average rate per pound of valuation 75 per cent., and the assessed values have been greatly increased. In addition the local authorities are not able to pay their way, but are running into debt at a rapid rate.

No public man in England is better qualified to speak on this subject than Lord Avebury (Sir John Lubbock). He has probably done more than any other man, both in and out of Parliament, for the working classes of the community. He was for years the chairman of the London County Council, and devoted himself to the arduous duties which that position entails. Lord Avebury is a man of business and scientific attainments, a close student of affairs and men, and the results of his observation, while dispassionately given, constitutes one of the most severe arraignments of extreme socialistic tendencies that has appeared in print. One of the elements tending to give great weight to his arguments arises from their broadness and sound common sense standpoint, as well as the well-known liberal tendencies of their author.

The postal treaty between the United States and Canada will expire on May 7th, and the Canadian Government now has before it a proposition to increase the rate of postage on periodicals from the United States to such an extent as will make it necessary for the publishers in this country to increase their subscription prices to Canadian subscribers from 50 to 100 per cent. If the Canadian subscribers to the ELECTRICAL AGE object to such an increase, it will be well to make known their objections at once to the Dominion postal authorities. The proposed increase in the rate of postage will make it impossible to mail the ELECTRICAL AGE to its Canadian subscribers at the present subscription price, except at a considerable loss.

News Notes

The National Electric Light Association has sent out a circular over the signature of Mr. Arthur Dow, Chairman of the Committee on Lightning Protection, requesting that information in regard to such troubles be sent to Mr. Robert S. Stewart, Penobscot Building, Detroit, Mich.

There is a lack of reliable information in regard to lightning and its effects, particularly in high-tension work. It is to be hoped that all members of the association will co-operate in the efforts to secure reliable information on this subject.

At the March 29 meeting of the Board of Directors of the American Institute of Electrical Engineers the following nominations were made for the coming annual election: President, Henry C. Stott, New York; Vice-Presidents, L. A. Ferguson, Chicago; W. C. L. Eglin, Philadelphia; James G. White, New York; Managers, Percy H. Thomas, New York; B. G. Lamme, Pittsburg; H. W. Buck, New York; Morgan Brooks, Urbana, Ill.; Treasurer, George A. Hamilton, New York; Secretary, Ralph W. Pope, New York.

The Electro Metallurgical Company, of Chicago, Ill., has taken over the manufacture and sale of the ferro-alloys, formerly made by the Willson Aluminum Company. The works at Kanawha Falls, West Va., will be operated by the former company, who are prepared to take care of all inquiries for these alloys.

A change of corporate name of interest to the trade took place April 1, 1907, when the Sawyer-Man Electric

Company became the Westinghouse Lamp Company. Thus the name of the pioneer company in the lighting industry passes into history. It has, of course, been generally understood for a number of years that the Sawyer-Man Electric Company was a Westinghouse interest, and the change of name is only a logical result of such conditions.

The Northern Engineering Works, of Detroit, Mich., have recently added to their facilities a trolley-erecting shop 50 feet x 100 feet., served by a ten-ton crane; and a two-story addition to their tool and storeroom, 30 feet x 50 feet. These extensions are of brick and steel construction with saw-tooth roofs. The necessities of increasing business made this addition necessary to meet the demand for "Northern" cranes.

Owing to the congested quarters in their old plant, the Steel City Electric Company, of Pittsburgh, has found it necessary to remove their shops to Allegheny. They now occupy an entire building, thoroughly equipped for their work, where they expect to be able to meet the growing demand for their specialties, the "Star" bushing, and the "Fullman" floor-box.

The Alberger Pump Company has been organized by those identified with the Alberger Condenser Company, to manufacture turbine and centrifugal pumps. The new company will be a joint occupant of the works and various offices of the parent concern. The new concern will place on the market a complete line of volute pumps, both single and multi-stage, adapted for steam or electric driving, and to suit the many lines of work to which such pumps are eminently well suited. The officers of the new company are Louis R. Alberger, president; George Q. Palmer, vice-president; B. W. Pierson, secretary and treasurer; Frederick Ray, chief engineer; all of whom are connected with the Alberger Condenser Company.

Reis and O'Donovan, 1123 Broadway, New York, have added a mechanical engineering department to their organization, in charge of Mr. R. W. M. Clark, formerly with the New York Steam Fitting Company. Reis and O'Donovan are now prepared to handle complete power plant heating and ventilating installations.

This concern is known by its electrical work on a number of substations for the New York Edison Company and the Brooklyn Rapid Transit Company.

The market price of platinum has fallen from $38 to $34 per ounce. This drop of $4 in the cost of the metal will probably be followed by a further decline.

At the annual meeting of the stockholders of the Joseph Dixon Crucible Company the old board, consisting of Edward F. C. Young, John A. Walker, Edward L. Young, William Murray, George T. Smith, Joseph D. Bedle and George E. Long, was unanimously re-elected. The board of directors re-elected the former officers, namely, E. F. C. Young, president; John A. Walker, vice-president and treasurer; George E. Long, secretary. Judge Joseph D. Bedle was also re-elected as counsel.

New Catalogues

A very neat pamphlet has been received from the Miller Saw-Trimmer Company, of Milwaukee, Wis., describing and illustrating their trimmer for use on electrotypes and slugs in printing offices. One of the noticeable features of this machine is the use of a vertical belt drive from a motor located under the machine, where it will receive all of the dust falling from the saw.

The convenience of the operator is sacrificed by locating the motor-starting box on the floor with the motor, where it will also receive its share of sawdust.

Such poorly considered drives as this are well calculated to injure the sale of motors not only for driving these kinds of machines, but in other lines as well. The arguments against the use of electric driving that spring from the improper applications of motors are very hard to overcome, and one badly designed application will not only prevent motor sales, but the sale of current for driving them.

The Kuhlman Electrical Company, of Elkhart, Ind., is distributing a booklet entitled, "Suggestions Pertaining to the Selection and Care of Transformers." In addition to the suggestions they call attention to the guarantee against burn-outs furnished with their transformers covering two years' service which, under certain conditions, may be extended to five years.

Bulletin 143 of the B. F. Sturtevant Company, of Hyde Park, Mass., treats of their generating sets with direct-connected engines, ranging in size from 20 to 150 k.w., giving in tabular form the main dimensions of each sized unit. This table is a convenient one for power-plant designers.

The Jeffrey Manufacturing Company of Columbus, Ohio., has got out an interesting pamphlet showing the varied industrial uses of their conveyors in the wood-working business.

The Chicago Fuse Wire & Manufacturing Company, of Chicago, has issued a pamphlet giving in compact form the useful information necessary for the use of their fuse blocks and cartridge fuses. They will be pleased to send a copy to those interested.

Personal

Harry N. Latey, Electrical Engineer of the Interborough Rapid Transit Company, was given a dinner at the Hotel Manhattan, New York, on April 12, 1907, by his friends and associates, among whom were George S. Rice, Chief Engineer of the Rapid Transit Commission; S. L. Deyo, Chief Engineer of the Interborough Company; G. H. Pegram, Chief Engineer of the Manhattan Railway, and D. D. Smith, Superintendent of Transportation, Manhattan Railway. Mr. H. G. Stott presided.

Mr. Latey will be associated with Mr. F. R. Slater, in the firm of Slater & Latey, who are Consulting Engineers for the Rapid Transit Commission.

Mr. William McLellan, who has been connected with Westinghouse Church Kerr and Company for a number of years, has severed his connection with them to enter the firm of Allison, Campion, McLellan Company, Consulting and Constructing Engineers, of New York and Philadelphia. Mr. McLellan recently had charge of a portion of the work in connection with the electric equipment of the Erie Railroad near Rochester.

Mr. W. T. Thomas has been appointed vice-president and manager of the Rumsey Electrical Manufacturers' Company, of Philadelphia. Mr. Thomas was formerly connected with the H. C. Roberts Electric Supply Company.

Mr. Clarence E. Delafield has been appointed manager of the high-tension insulator department of the Ohio Brass Company, of Mansfield, Ohio. Mr. Delafield was formerly connected with the Wagner Electric Manufacturing Company.

Mr. E. P. Dillon has been appointed general manager of the Pike's Peak Hydro-Electric Company, of Colorado Springs.

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Editorials

Leading Articles

The Induction Motor

ELSEWHERE in this issue appears the first installment of an article by Mr. C. J. Spencer on the induction motor. This type of machine, as the author points out, may be considered as a generator, with the difference that the power generated in the motor is lost in heating the secondary, and the total power generated, including secondary C^2R losses, is taken into account in calculating the motor output, while the generator output consists of the total power generated, less the armature C^2R losses.

A point not brought out very clearly by the author is that the comparison between these two types of machines is made with both operating with constant effective field strength at different speeds. Generators are normally operated at constant speed, with varying field strength when of the compound-wound type, and at constant speed with constant field strength when shunt wound.

The latter type of generator is evidently the one with which this comparison is made, as the strength of field is shown to diminish with increase of load, due to the reaction of the magnetizing turns of the secondary, in much the same way as the strength of a shunt-wound generator field diminishes from the demagnetizing effect of the armature.

The discussion of this subject is of interest, as it fills in the gap between the non-technical descriptions of this type of motor and the intensely technical text-books on this subject, enabling those who care to study the design of induction motors to follow the mathematical treatments without difficulty. Indeed, most of the designers of motors neglect to describe all the reactions which take place, the well-known Heyland circle diagram being constructed without regard to the CR drop and reactance drop, which will be shown in a later issue to have a very appreciable effect on the motor performance.

Some authors introduce imaginary quantities, a branch of mathematics not developed to the same extent as trigonometry. Trigonometrical formulæ admit of reducing complicated equations to a few simple numbers, and the tables of sines and tangents available in all hand-books are of immense advantage in calculating the dimensions of sides and angles of geometrical figures. Moreover, the calculating rules—slide rules—contain indexes by means of which angles may be readily multiplied and divided, or one side of a triangle may be expressed in terms of any other side when the angles are known.

Dimensions are given in inches, the customary method of English-speaking people, and reduced to centimeters, as required for making the magnetic calculations. It is to be regretted that the electrical units of measurement are so connected with the magnetic units that the English method of measurement does not admit of reducing electrical values to magnetic values, or vice versa, without introducing constants not familiar to the electrical public. It would be a great boon to the electrical engineer if this country should adopt the c. g. s. system and thus do away with this conversion of centimeters to inches and grams to pounds.

Heaviside worked long and laboriously to eliminate the constant 4π which occurs in converting electrostatic to electromagnetic units, but without success. The constant is there to stay and will always be a stumbling block in the path of the electrical profession. Likewise the constant connecting inches and centimeters must be reckoned with, for the present at least.

The author deserves commendation for reducing to a few simple triangles the complicated diagrams now so familiar in connection with transformers having stationary and moving secondaries. As he expresses it, the great need of modern times is to clear away the cobwebs and do away with long equations.

Relative Capacities of Distributing and Generating Systems

THE economy obtained by combining many central stations into one generating system, either by tying the stations together with interconnected feeders or by replacing the stations by one large central station, is due to improved load factor thus obtained. Any part of the distributing system carries its greatest load at a certain time of the day. Feeders which supply traction systems supply their greatest load at certain hours of day and night; feeders which supply power for industrial work supply their greatest load at other hours of the day, while feeders for lighting offices, theaters and private residences each have different times of peak load. Central station managers exert their best efforts to obtain customers who demand power at times of light load on their stations and to prevent the heaviest loads on the different feeders from occurring at the same time, that is to say, they endeavor to improve the station-load factor.

Load factor and relative capacities of distributing and generating systems are intimately connected. A station having a load factor of sixty or seventy per cent. may have a capacity for generating power very much smaller than the total capacity of the distributing system, where power is distributed for many purposes.

Special cases occur where the station supplies one class of power or light only and where the power factor is good, for instance, stations used to generate power for factories running day and night, and those generating light for tunnels. These, however, are not considered here, except to state that with these conditions the capacities of distributing and generating systems are equal.

For large central stations operating compound with many different kinds of loads, the station capacity may be as low as fifty per cent. of the capacity of the distributing system. Smaller stations must have a capacity of about seventy-five per cent. of the distributing system. With the average electric light plant which does not have a large business with office buildings, the station capacity cannot safely be less than the capacity of the distributing system, for, while the station capacity may not be utilized during the greater part of the year, there is always a demand for light during the Christmas holidays that is sure to require forcing the station equipment to its utmost.

The Institute Library

NOW that the library of the American Institute of Electrical Engineers is commodiously quartered in an accessible place, it would be a real pleasure for engineers to use it; but, unfortunately for them, the hours during which the library is open coincide with business hours, and hence any extensive use of the library by men closely employed is impossible. It is to be hoped that the Conference Library Committee will take this matter in hand promptly and make some arrangement whereby the library may be open evenings and Saturday afternoons.

It is not generally understood that the libraries of the American Society of Mechanical Engineers, and of the American Institute of Mining Engineers are placed in alcoves in the same room with the Institute library, and are open for use to the members of the Institute. The several collections are too valuable not to have wider use in metropolitan New York, which contains approximately 10,000 engineers to whom they would be of value.

Practically no use was made of the Institute library in its old quarters, except as members made use of reference works. It is understood at the present time that the attendance averages eighteen daily. The establishment of evening hours and a full day on Saturday would probably increase its use ten-fold.

Capacity of Regulators

THE capacity of a regulator whether employed for raising the voltage of a rotary converter or for potential regulation of a feeder, is found by multiplying the current in amperes by the increase or decrease in voltage. The reason for this is not clearly understood, some engineers holding to the idea that the regulator is similar to a transformer and must have a capacity equal to that of the apparatus supplied.

All the power of a feeder is transformed in a step-down transformer. Let the voltage be 2000 volts and the current 10 amperes, then a 20 k.w. transformer is required for transforming this voltage to a higher or lower value. A potential regulator which would give 10 per cent. regulation on this feeder would raise or lower the voltage 200 volts; the current is 10 amperes, then the required capacity of the regulator is 2 k.w. for a single-phase circuit.

Rotary converters are usually three-phase, or two-phase for the older types, and of late the six-phase rotary has come to be quite common, especially in the larger sizes. In any system the capacity of the regulator is the sum of the capacities obtained by multiplying the current by the increase of voltage in each leg of the system. Some misunderstanding is caused by measuring the voltage between wires of a delta-connected three-phase system and multiplying this increase in voltage by the current per wire. In the delta-connected system, the current in the individual legs or branches is not equal to the current per wire, but is $\frac{1}{\sqrt{2}}$ of this value, consequently the current per wire must be reduced in this ratio when finding the capacity required of the regulator.

High-Voltage Generators with Grounded Neutral

ONE of the latest ways of protecting high-voltage systems from over-voltage surges is to connect the neutral of one or more generators to ground through a resistance. This resistance to be effective must have a high ohmic value and large amperage capacity, and is for this reason expensive and requires considerable space in the power-station.

The cost and space required for a resistance of this nature leads to the question of the desirability of supplying more than one resistance.

Over-voltage surges may be produced outside of the station or from switching the generators on and off the bus-bars inside the station. When the trouble is external to the station one resistance affords ample protection to the system. The other source of trouble, that due to opening the generator circuit or connecting the generator in parallel with another machine when not exactly in step, cannot be guarded from doing damage with one resistance. It might be argued that the neutrals of two generators can be connected before the generators are connected in parallel at the switchboard. In this case no more protection is provided for trouble between the generators than would be obtained by connecting both generator neutrals directly to ground without the resistance.

For protection from over-voltage surges outside the station one resistance is sufficient. For protection from over-voltage surges inside the station a resistance must be provided for each generator.

Why Public Service Corporations Should Look Ahead

A NUMBER of years ago the president of a large railroad corporation said, "The public be damned," in reply to a question of great public interest. The point of view which was taken by the late Commodore Vanderbilt is that which for many years governed the executive officials of public service corporations. The result of such selfish and short-sighted methods has been the growth of serious public sentiment against the ownership of public utilities by private corporations or individuals. To the managers of such corporations the drift of public sentiment is of great importance not only to themselves but, in a larger measure, to their stockholders and those who own bonds and other securities of such companies, to whom the management is directly responsible, and upon whom the suffering will fall should the income from such securities be jeopardized.

The seriousness of the situation should not be belittled, and the columns of the daily papers, to an increasing degree, bear witness to the hostility of a portion of the general public toward all public utility corporations. This sentiment is not confined entirely to the columns of the "yellow" journals, but has gathered sufficient headway and weight to attract the attention of papers noted for their conservative tendencies.

The Wall Street Journal on April 10th printed a letter from Mr. W. J. Bryan in regard to the government ownership of railroads.

This letter was not a spontaneous effusion, but was written by editorial request, and was extensively commented on in the editorial column.

On April 8th the New York *Sun* gave three columns on its editorial page to a letter from a noted radical, Mr. Thomas A. Watson, now of Boston, Mass., whose views on the subject of dealing with the public service corporation are as follows:

"The company shall be reorganized so as to allow the election of, say, eight directors, to be chosen four by the stockholders, four to represent the public in such manner as may be authorized by the legislature, two of the four selected from the employees and representing them as well as the public. The board of directors shall have full supervision of the company's affairs.

"The city shall give an exclusive franchise for operating railways in its streets for a certain term of years.

"The city shall guarantee a minimum dividend of, say, 2½ per cent. on the capital stock of the company—that is to say, if the net earnings of the company in any year are not sufficient to pay a dividend of 2½ per cent., then the city shall pay into the treasury of the company a sum sufficient to enable it to do so.

"The company shall be allowed to pay its stockholders from its net earnings a maximum dividend not exceeding 7 per cent. per annum on its capital stock.

"The city shall be paid by the company an amount equal to one-quarter the amount of the dividends paid to the stockholders.

"Employees shall receive standard wages and work standard hours. For each ¼ per cent. in dividends paid stockholders more than the minimum dividend of 2½ per cent., employees' wages shall be increased 1 per cent. Whenever the net earnings of the company are not sufficient to allow the payment of the minimum dividend of 2½ per cent., employees' wages shall be reduced 1 per cent. for each ¼ per cent. by which the earnings fall short of this minimum."

This suggestion was further dignified by being made the subject of the leading editorial of that issue, and the following comments were made thereon:

"*The Sun* recently suggested the possibility of establishing a community of interest between the State and the creature of the State, the public utility corporation; a Government partnership as a national alternative to the impracticable idea of Government ownership.

"With Government partnership once recognized as a principle, there would be little difficulty in finding efficient means for carrying it into practice. The idea seems to be in the air. In Mexico, for instance, a gigantic merger is about to include nearly all the leading railways in one great corporation. The Government assumes control of this company simply in return for a guarantee of the second mortgage bonds. Here public control and private management are combined, the latter assuring the desired flexibility and efficiency.

"Should the present very general antagonism to corporations as such continue to express itself in meddlesome regulations and burdensome restrictions it might soon become impossible to secure the means necessary for proper public service. That is why some intelligent minds are contemplating the possibility of averting such a calamity by some judicious form of Government partnership in the administration of public utilities."

In connection with the foregoing it is of interest to note the views of Mr. W. H. Gardner, as recently expressed in a speech before the New England Association of Gas Engineers, in the course of which he said:

"I believe that the greatest problem before our country to-day is the rational co-ordination of the rights and interests of the corporations (and especially the quasi-public corporations) and those of their customers, the great public, for whose service they exist.

"The extremist, finding fault with the corporations, would destroy them and throw the burden of conducting these services upon our Government. This attitude is but the natural antipode of the attitude held by many corporation men, that the conduct of a corporation is a private matter which concerns not the public.

"Between these two extremes I believe there is a just mean. I believe that you here in New England, in Boston, have taken the first step toward its solution. About a year ago you inaugurated under your commission system of Government supervision a plan whereby the profits of your gas company are made inversely proportional to the price at which it serves the public. As it reduces the price of gas, it is allowed to pay proportionally larger net earnings. While I have never approved of some of the details of this system as applied in Boston, I believe that it contains the germ of the solution of the public utility problem throughout the country. I believe this because this sliding scale copartnership which you here have between the public and the gas company retains all the advantages of individual initiative and allows proper incentive under a most commendable system of Government supervision, which exacts a "square deal" both for the public and the corporation.

"Personally, I am an earnest advocate of the Governmental supervision of public utility companies, and I look to the extension of Governmental supervision. But I hope that in it will always be incorporated the principle of profit sharing alike to the public and the corporation as you have it here. I believe that the basic principles of this profit sharing are applicable in some forms, perhaps as yet undeveloped, to electric lighting, traction and even to the Governmental supervision of our great railroads. Thereby we can get from these utilities the maximum efficiency of service resulting from individual initiative, they receiving personal gains proportional to the service rendered the public."

Mr. Gardner's views on this subject should carry considerable weight, as he has had a wide experience in the administrative affairs of public utility companies.

There is another dark cloud in the sky, in the shape of the "Public Utilities" measure passed by the New York State Legislature. This bill places the supervision of such corporations in the hands of a commission whose acts will not be subject to judicial review in the courts, and who must pass on all applications for franchises. The commissioners are to be appointees by the governor.

It is needless to comment on such a menacing measure as this. When the commission goes into power it will probably remain with power long after the strenuous reform administration responsible for the measure has retired from office.

Arc Lamp Costs

THE following current costs for the municipal lighting plant of Grand Rapids, Mich., are of interest as disclosing a situation that is likely to repeat itself with much frequency. The Grand Rapids and Muskegon Power Co. have contracted to deliver current to the municipal lighting plant at 5 cents a lamp-hour, whereas plant operation by steam shows a cost in excess of 7 cents.

From April 15, 1905, to March 31, 1906 (11½ months), 2,319,188 lamp-hours cost delivered to switchboard .007327 cent per lamp-hour: from April 1, 1906, to January 31, 1907 (10 months), 2,191,560 lamp-hours cost delivered to switchboard .007463 cent per lamp-hour.

Formerly the plant was operating on a partial moonlight schedule with lights in the downtown business districts burning all night and every night, utilizing the moon in the outlying districts after 10 o'clock P. M., when not obscured by clouds. The average hours' operation per night for all night and every night was 10 hours and 15 minutes, or 3741 operating hours per annum.

The Grand Rapids and Muskegon Power Company have contracted to furnish current delivered to the switchboard of the present city lighting plant for one-half cent per lamp-hour, on a basis of 800 lamps burning every night and all night regardless of the moon, and additional lamps pro rata. On the basis of 3741 operating hours per annum, 800 lamps will have 2,992,800 lamp-hours per annum, and at one-half cent per lamp-hour will cost $14,964 per annum.

According to the former moonlight schedule there was an aggregate of 2,629,872 lamp-hours at a total cost of $19,626.84 delivered to the switchboard. To operate all lights all night and every night would have required 362,928 additional lamp-hours per annum, or an increase in cost of $1,500, or a total cost of $21,126.84, with a net saving to the municipality of $6,162.84 per annum.

The Grand Rapids and Muskegon Power Company assumes all initial expense in the purchase and installation of electric motors and appurtenances necessary to make the change, belting the present arc generators from these motors, and allowing them to remain in their present locations, so that should occasion require they could be belted and run from the engines, as at present. The power company maintains and operates the entire plant delivering the current at the switchboards to the street lighting circuits.

Experience in Selling

IT was decided by the board of directors of the C. N. & D. Co. to drive their mill electrically with direct-current motors. The mill was two and one-half miles away from the power plant of a central station which put in a bid for power at a figure (3 cents per kilowatt-hour) which made it undesirable to put in a private plant. There was no competent engineer in the central-station company to pass on the matter and the commercial department assumed the contract at a rate equal to what it was making to smaller power customers, figuring roughly that the cost of the copper line would be offset by selling so large an amount of power at regular power rates.

The 220-volt service at the power-station was carried down to the plant by two 500,000-c.m. cables, and the equipment and motors were installed. When the current was turned on the motors would not carry load and a measurement of the voltage showed 90 volts at the motor. The torque was just about one-quarter of what it should have been.

Of course there was no alternative but to tear out the line and substitute a larger cable. Accordingly a new set of 600,000-c.m. cables were put up, making an investment of $15,000 in copper. This remedied the matter somewhat as the motor voltage was now 160 volts, but still the torque was low, and when the motors made a heavy demand on the current the torque lessened, so that when any considerable number were operating simultaneously their load performance was unsatisfactory.

Shortly after the plant was put in operation the fluctuating motor load brought trouble. A crane dropped $1,500 worth of metal from a molten ladle, and the likelihood of a repetition had to be prevented. This was done by floating a $10,000 storage battery at the end of the feeder line, which, of course, remedied the voltage variation.

It is needless to say that this power contract is a losing one to the central-station company. The copper cost was 50 per cent. higher than was contemplated, the cost of erection was more than doubled and a storage battery brought the cost up to about double the original estimate. A competent engineer could have saved that company several years' salary, and a consulting engineer's fee would not have amounted to 2 per cent. of the additional cost.

Power for Wood-working Tools

Announcement was made that in this issue would appear an article with the above title. We regret, however, that lack of space compels us to hold it for the June issue.

Notes On Carbon-Dioxide Recorders

THE question of fuel economy is one of the utmost interest to central station managers, and the means by which such economy can be obtained are being seriously studied. It is well known that a large amount of fuel heat is wasted, owing to imperfect combustion in the furnace, and that a large part of this loss is due to the excessive air supplied the fires. One of the methods of checking this loss is by the analysis of the flue gases, the proportion of carbon dioxide in the waste gases being a fair index of the amount of heat that is wasted. Apparatus designed for the analysis of flue gases has been known for years in chemical laboratories, and is often used in boiler tests. The best known device for this purpose is the Orsat apparatus, which, owing to its portability, is very convenient for temporary purposes. It does not, however, meet the demand for a continuous record of the results of combustion. The analysis of flue gases by the Orsat apparatus requires about one-half hour, including the time required to obtain a sample of gas, when all preparations for such work have been made in advance. The sample taken is 100 cubic centimeters, an infinitesimal amount as compared with the volume of gas passing through the flue, and there is no certainty that it is an average sample. In addition to indicating the amount of carbon dioxide, the Orsat apparatus gives the percentage of carbon monoxide, oxygen and nitrogen, which are present in the gases, and this information is necessary to complete the data in regard to the conditions of combustion. A low percentage of carbon dioxide alone is simply an indication of something wrong, and different methods must be used to remedy this condition, according to whether the defficiency in carbon dioxide is accompanied by a surplus of oxygen or carbon monoxide, the latter indicating partial combustion, the former air leakage, either through the fire or the boiler setting.

The carbon dioxide recorder has been designed to meet the demand for an instrument which will give a continuous record of carbon dioxide in the products of combustion, doing so automatically. There are several makes of apparatus on the market which attain this result by different methods, with more or less success. To obtain accurate results it is not only necessary to know the percentage of carbon dioxide, but the temperature of the waste gases as well, since both have their influence on the question of fuel economy. Changes in the temperature of the atmosphere and the barometric variations also affect the result, and parallel records of the draft and the steam pressure and temperature are of value.

to 70 per cent. of the operating expense of a plant. A reduction in fuel consumption per unit of output is a very effective method of reducing expenses. The diagram, Fig. 1, shows graphically the amount of heat lost with varying percentages of carbon dioxide, at various differences in temperature between the entering air and the waste gases of combustion. Experiments have shown that the most profitable rate for the combustion of coal is obtained when the chimney gases contain from 10 to 14 per cent. of carbon dioxide, and in the use of gas fuel with about 17 to 18 per cent.

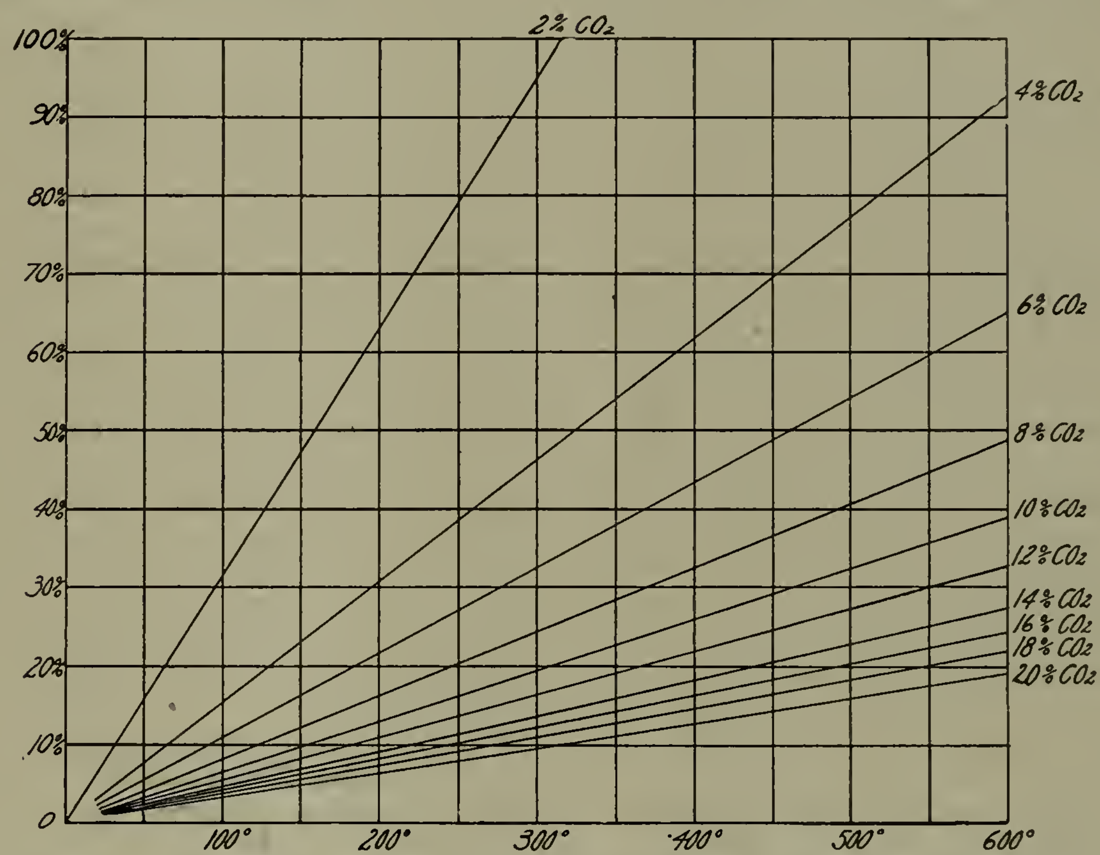


FIG. 1.—SHOWING THE AMOUNT OF HEAT LOST WITH VARYING PERCENTAGES OF CARBON DIOXIDE.

The following table shows approximately the amount of surplus air indicated by different percentages of carbon dioxide in the flue gases:

Carbon dioxide per cent.	Surplus of air over the theoretical amount required	Percentage of heat lost with the flue gases at +500° F.
2	8.5	90
3	5.3	60
4	3.7	45
5	2.8	36
6	2.2	30
7	1.7	26
8	1.4	23
9	1.1	20
10	.9	18
11	.7	16
12	.6	15
13	.5	14
14	.4	13
15	.3	12

From this table it will be seen that there is a large opportunity to waste fuel through ill-considered methods, when the expense for fuel is from 60

The carbon dioxide recorder affords a convenient method of keeping track of the approximate fuel economy obtained, but by itself it is liable to be somewhat misleading, and to obtain the full value of its service it is necessary to have other continuous records showing the temperature of the atmosphere and the waste gases, the draft, barometric and steam pressures and temperatures, as all of these variables have their effect upon the combustion of fuel and must be considered in an intelligent study of the subject. In fact, it is possible to show a very economical result judging by the recorder diagram, while the actual steaming conditions are poor.

Of necessity, the carbon dioxide recorder is a delicate piece of apparatus and must be installed at some point where it can be watched and taken care of. This consideration introduces pipe connections of greater or less length between the instrument and the flue from which the gases are drawn; and, therefore, unless some means are used to produce a constant current of gas through this tube the recorder will be from two to ten minutes behind the furnace. Even when an aspirator is used there is a perceptible lag, owing to the difference between the velocity of the gases in the flue and the pipe connection.

One type of recorder operates on samples of the gases drawn in at intervals. This method of operation is inherently less accurate than that in which a continuous current of gas passes through the instrument. The samples are taken at intervals of several minutes, and it is possible for a fireman watching the recorder to perform nearly all of the work which admits surplus air to the furnace during the periods in which no samples are taken; thereby securing a good card on the recorder, though its indications are of small value. Other types of recorder operate by weighing the gases which pass through them continuously. These instruments are very delicate, owing to the scale required to detect the slight differences in the specific gravity of the gases. This type of instrument must be accurately leveled and located where it will not be subject to vibration or shock. The more sensitive this instrument is, the less it is suited to use in the boiler room. These instruments are made both with and without the automatic recorder. One of the weak points of the scale type of construction arises from the impossibility of shielding any of the metallic parts of the scale from the corrosive action of the sulphur fumes so often present in the gases of combustion. Glass parts are often used in these scales, and while the metallic portions are gold plated, long usage results in gradual corrosion of the knife edges and loss of accuracy. A third type of recorder operates on the principle of the flow of gases through small apertures into a partial vacuum, the gases being drawn into a chamber through an opening and passing from this chamber through another opening into a second chamber in which a partial vacuum is maintained. The two apertures are of the same size, and means are provided for maintaining them and the flowing gases at a constant temperature. As long as the same volume of gas passes both apertures the vacuum in the first chamber will be one-half the vacuum in the second; but if after passing the first aperture one of the constituents of the gas be removed, its volume is reduced and the vacuum in this chamber will be increased. This difference in the vacuum will be an accurate measure of the amount of gas absorbed. This method of handling the gas has been thoroughly tried out and has proved very accurate, the instrument having been used for a number of years in blast furnace practice in furnishing records continually for four or five years, with twenty-four hours per day operation.

In the type of instrument first mentioned and the third, caustic potash or potassium hydrate solution is used to absorb the carbon dioxide. This solution has a high affinity for carbon dioxide gas, though its absorption capacity naturally becomes less as it approaches the saturation point. For accurate work, even where the gases are bubbled up through the liquid, it is advisable to use a fresh solution as soon as each cubic centimeter of the solution has absorbed 40 cubic centimeters of carbon dioxide. Surface absorption, where the solution is not disturbed, is very slow, and unless a long time interval is given to the absorption period, the readings will be inaccurate, the extent of the inaccuracy increasing with the length of time the solution remains in use. In fact, surface absorption can only be used with an instrument taking samples at intervals. When a continuous sample is taken, a different method must be adopted to bring the solution and the gases into close contact. The gas is therefore passed up through a reservoir, which is filled with quartz pebbles, which are kept moist with the potassium hydrate solution. The solution flows through this reservoir by gravity, and means are provided for regulating the rate of flow.

From the foregoing description of the methods of operation of the different types of carbon dioxide recorders, it is readily seen that the continuous sample instrument affords the most accurate record, and is therefore a more desirable instrument.

The cost of installing these recorders varies greatly, ranging from $225 to $600, according to its attachments. The connections and fittings in the plant will often cost as much more for each instrument. A large plant will require several instruments, a small plant can get along with one. It is not desirable to allot more than six boilers or furnaces to one instrument, but there is no limit to this number when only partial records are wanted. A complete installation covering the carbon dioxide recorder and recording thermometer, pyrometer, draft gauge, barometer and steam gauges is necessarily more costly. And where these autographic recording devices are reinforced by instruments to record the temperature of the saturated and superheated steam, the latter not only at the boiler outlet, but at the throttle as well, it is evident that a considerable amount of money can be put into these refinements.

The results to be attained by such an investment will, to a large degree, depend upon the intelligent study made of the records. The use of the carbon dioxide recorder alone has in many cases reduced the fuel consumption from 8 to 10 per cent., owing to the fact that more intelligent methods of firing were introduced when the recorder made the loss-up-the-stack visible. It would not pay to install a complete system of recorders in any plant with a fuel bill less than $15,000 per annum, but it would pay to install one of the less complicated forms of apparatus in any plant whose fuel bill was $2,000 per year or more.

The Induction Motor

By C. J. SPENCER

THE induction motor may be considered as a generator, with the difference that the power required to hold the rotor (secondary) from turning, that is, the brake horse-power developed corresponds to the power required to turn the armature of the generator. The speed of the motor secondary equals that of the primary field when no power is developed. Now, suppose the motor to be belted or geared to some machine which requires power to drive it. The secondary is partially held from turning and generates electric power. The amount of power developed is shown below to equal the amount of electric power generated multiplied by $\frac{1 - \text{slip}}{\text{slip}}$.

An electric generator, which delivers 50 electrical horse-power, requires a little more than 50 horse-power to drive it. The generator field is stationary. An induction motor running at synchronous speed does not develop power. If the motor be attached to a machine and the secondary slowed down to a speed at which 50 electrical horse-power is generated, the brake horse-power developed will depend on the synchronous speed and on the slip.

The torque on the pulley of the generator when generating 50 electrical horse-power, or 1,650,000 foot-pounds per minute, is 1650 foot-pounds with a pulley 10 feet in circumference, and a speed of 100 revolutions per minute. The torque on the same size pulley on the motor shaft when the motor develops 50 electrical horse-power, or 1,650,000 foot-pounds per minute, at 100 revolutions per minute less than synchronous speed, is 1650 foot-pounds. A six-pole motor on a 60-cycle circuit has a synchronous speed of 1200 revolutions per minute. The reduction in speed of 100 revolutions per minute gives a speed of 1100 revolutions per minute, amounting to 18,150,000 foot-pounds per minute with the above torque of 1650 foot-pounds.

18,150,000 foot pounds per minute = 550 horse-power.

The slip of 100 revolutions per minute is .0833 of synchronous speed.

$$50 \text{ h.-p.} \times \frac{1 - .0833}{.0833} = 550 \text{ h.-p.}$$

The resistance loss is 50 horse-power and the developed power is 550 horse-power; then the efficiency of this motor cannot be better than 91.67 per cent. The input is 600 horse-power and the output is 550 horse-power, no other losses being taken into account except the C^2R loss in the secondary. A motor with squirrel-cage secondary cannot be made with a high efficiency and large slip, consequently this type of motor is best adapted to constant-speed work, and the best designs have close speed regulation and high efficiency.

Where a variable-speed induction motor with the squirrel-cage winding is installed, the work is generally of an intermittent character, such as short hoists; otherwise the heating of the secondary makes necessary large collector rings, making the motor large and expensive. It is cheaper to install a motor with wound secondary and collector rings for variable-speed work where the load is carried at reduced speeds for any length of time, external resistances taking up the losses. The high-resistance secondary has the desirable feature that the motor can be handled by rough workmen, overloads having the effect of reducing the speed so that the actual power required is reduced and the torque increased. Where slight sparking is not objectionable, the same results obtained by the motor with high-resistance secondary can be obtained by the motor with wound secondary and a resistance connected permanently in circuit.

With the functions of the secondary thoroughly understood, the motor reactions are readily calculated as closely as current and voltage readings are usually measured on commercial circuits. Precision meters of the zero reading type give extremely accurate results and should be employed wherever extreme accuracy is required. Ordinarily, however, a reading within 1 per cent. is considered as correct, so it is not necessary to take account of unimportant details which affect the results but slightly, except to allow a sufficient margin for these items.

The secondary may be wound with wire on either the two-phase or three-phase system regardless of the primary winding. It may also be wound with closed loops of wire, or conducting bars may be threaded through slots in the circumference and the ends joined by connecting rings, this construction making the well-known squirrel-cage winding. All that is necessary is some system of conductors in which electric power may be generated. Obviously, the bars may be of any size and eddy currents produced therein should not be accounted a loss, as they will have the effect of producing a higher full-load speed. With very large bars an allowance must be made for these eddy currents when calculating the motor speed.

The squirrel-cage secondary is the most common form, being generally adopted on account of simplicity. It is difficult to calculate the resistance of the many circuits in this secondary because of the dependence of each circuit on some other circuit, as the current in the end rings flows through several bars. Usually the resistance of the bars is neglected and the resistance of the end rings made of a value to obtain the desired slip. Other manufacturers neglect the resistance of the end rings and make the resistance of the bars sufficient to give the desired characteristics. This method is open to the objection that the heat is radiated through the motor interior. It will be shown that neither the resistance of the bars nor the resistance of the end rings can be safely neglected.

A simple method of calculating the apparent resistance of a squirrel-cage secondary is to assume that the current in consecutive bars varies as a sine wave function of the distance of the bar from the pole center, this distance being measured in electrical degrees. The field set up by the primary very closely approximates a sine wave and the current induced is approximately proportional to the field when the resistances of the end rings and secondary bars are within customary limits.

To assume that the current varies directly with the inducing field is equivalent to assuming that the secondary is a perfect current transformer. If the end rings be removed, the voltage induced in the secondary bars will vary directly with the inducing field. The resistance obtained is not the same when the voltage is assumed to vary directly with the field as when the current is assumed to vary in this ratio, but with low resistance bars and end rings the induction motor is so nearly a perfect current transformer that there is no appreciable error in assuming this to be the condition. It is sufficient to know that in calculating the resistance of a secondary, with high-resistance end rings, an allowance must be made for the values of the current in the bars departing from the sine function ratio and the voltage more nearly approaching these valves.

The number of bars in the secondary is made one more or one less than

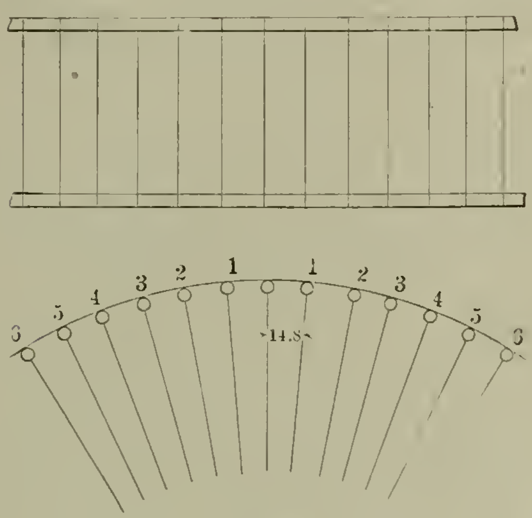


FIG. 1.

an even multiple of the number of poles, in order to avoid a pulsating torque. When twelve bars per pole gives about the proper spacing, a six-pole motor will have 71 or 73 bars. Take 73 bars as the total number of bars in the secondary. At some time the angles of the different bars from the center of the wave of magnetic flux are as shown in Fig. 1. Only one pole is shown.

There are 73 bars for a six-pole motor, which gives 12.167 bars per pole; one pole is taken to include one-sixth of the secondary circumference with a distributed winding. The electrical angle subtended by an arc of this magnitude is 180 degrees. The electrical angle from one bar to the next adjacent bar, found by dividing the total angle by the number of bars in the arc which subtends it, amounts in this case to 14.8 electrical degrees. A table is compiled and printed below giving the angles of six bars from the center and the relative values of the current in the different bars.

Bar No.	Electrical Degrees.	Natural Sine.	Relative Values of Current.
1	14.8	.2554	.2554
2	29.6	.4939	.4939
3	44.4	.6997	.6997
4	59.2	.8590	.8590
5	74.0	.9613	.9613
6	88.8	.9998	1.0000

The natural sine of 88.8 degrees is so close to unity that its value may be taken as unity without reducing the values of current in bars Nos. 1 to 5 to their exact relative values. Values of the natural sine for the different angles are taken from any trigonometrical tables.

When one ampere flows through bar No. 6, the current in bar No. 5 is .9613 amperes, in bar No. 4 it is .8590 amperes, etc. The current in the end rings between bar No. 6 and bar No. 5 is one ampere, that between bar No. 5 and bar No. 4 is 1.9613 amperes, that between No. 5 and No. 4 is 2.8203 amperes, etc. The current between bar No. 1 and bar No. 1 on the other side of the neutral bar is the sum of the values of current in bars Nos. 1 to 6 inclusive and equals 4.2693, or 4.27 amperes.

The resistance of each bar is calculated from its dimensions and the known resistance of a square mil foot of copper obtained from any electrical hand-book. End rings are usually made from some metal alloy, the specific resistance of which is known, and with this information and the dimensions of the end rings the resistance from bar to bar is calculated.

Take the resistance of each bar from the center line of one end ring to the center line of the other end ring as .00005 ohms, and the resistance of the end ring from the center line of one bar to the center line of the next adjacent bar as .000002 ohms. The resistance in each case is taken from center to center of bar and ring to allow for the flow of current at contact surfaces.

If we find the volts drop around any complete circuit for one ampere in that circuit, we shall know the current for any voltage induced in that circuit. The volts drop in bar No. 6 is equal to the current, one ampere, multiplied by the resistance of the bar; the volts drop due to inductance is introduced later. One complete circuit is through bar No. 6, thence along the end ring to bar No. 6 on the opposite side of the neutral bar and back along the other end ring. Since there are different amounts of current in the end rings from one bar to the next, the volts drop must be figured for each section of the end rings and the results added to obtain the total drop. This is done as in the table below:

1 amp.	×	.00005 ohms	×	2 bars	=	.0001 volts
1 "	×	.000002 ohms	×	4 sections of end rings	=	.000008 "
1.96 "	"	"	"	"	=	.00001568 "
2.82 "	"	"	"	"	=	.00002256 "
3.52 "	"	"	"	"	=	.00002816 "
4.02 "	"	"	"	"	=	.00003216 "
4.27 "	"	"	"	"	=	.00003416 "
Total						.00024072 volts

The volts drop per amperes is .00024 volts, therefore the resistance for the circuit is equivalent to .00024 ohms.

A motor with secondary bars of high resistance compared to the resistance of the end rings, is purposely taken for example to show the error of neglecting the resistance of the bars and considering the resistance of the circuit as due to the resistance of the end rings alone. The resistance of the bars in the circuit is nearly one-half the total resistance of the circuit, and the motor slip will be nearly twice as great as calculated from formulæ which neglect the resistance of the bars. While variations in manufacture cause motors to have characteristics slightly different from calculated, there is no excuse for following for-

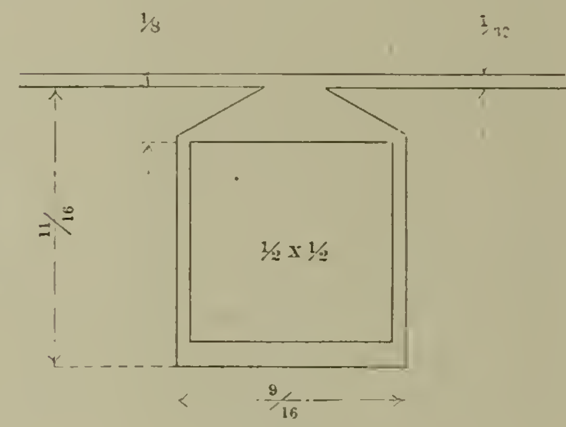


FIG. 2.

mulæ which give results with errors of this magnitude.

The reactance of a squirrel-cage secondary can be neglected for slips less than 10 per cent., so far as the drop in voltage is concerned, for the frequency of current alternation at small slips is so low that the reactance is inconsiderable. This reactance does affect the relative angles of magneto-motive forces of primary and secondary, and an error will be incurred if this item is neglected.

The error is small in some cases, but in others it is large. To be on the safe side, it is best to calculate the effect of the secondary reactance at 10 per cent. slip, and, if found small enough to be neglected at this slip, it may be neglected for smaller slips. In making up characteristic curves, the calculations for large slips, that is, at low speeds, are of great value. They give the pull-out torque of the motor and the current at starting. The calculation of the secondary reactance cannot, therefore, be evaded.

The reactance of the secondary is obtained from the dimensions of the slots and bars, and an estimated amount is added for the reactance of the end rings. To calculate the reactance due to the end rings would require so many assumptions that the entire reactance may be assumed with equal accuracy.

Cross-section dimensions of a slot and bar are given in Fig. 2. Take the length of the bar in iron as five inches. Part of the leakage magnetic flux goes through the air gap and does not oppose the primary flux; another part passes from iron to iron between the copper bar and along the diameter of the secondary; a third part passes through the copper bar from one side of the slot to the other side of the slot and links with part of the bar.

Take the leakage flux of the secondary as flowing through one-half the air gap, leaving the remaining half for the leakage primary flux. The length of path in air is $^9/_{16}$ inches and the area is $^1/_{64}$ inch by 5 inches. Reduce these inches to centimeters.

$^9/_{16}$ inch = 1.43 centimeters.
$^1/_{64}$ " = .0397 "
5 " = 12.7 "

Substituting these values in the formula:

$$\frac{4\pi}{10} = B\frac{1}{a}$$

$$\frac{4\pi}{10} = B\frac{1.43}{.0307 \times 12.7}$$

B = .442 c.g.s. lines per amp.

With one ampere in the bar, there are .442 c.g.s. lines produced in the leakage path through the air gap. One c.g.s. line cut per second by a circuit produces in that circuit 10^{-8} volts. Consider the one ampere as the maximum value of the alternating current in the bar; then the flux found above is the maximum value of the alternating flux. This alternating flux increases from zero to a maximum, reduces to zero, reverses to a maximum negative value and reduces to zero during the interval of one cycle.

On a 60-cycle circuit with the secondary at standstill, the average rate of cutting is $^1/_{240}$ second. The average volts induced are $10^{-8} \times 240 \times$ c.g.s. lines, where the maximum value of the c.g.s. lines is taken. Maximum values of alternating e.m.f. or any other function which varies as a sine wave are $\pi/_2$ times the average values. The maximum e.m.f. is $\pi/_2$ times the above value. Taking advantage of this fact, we may multiply the frequency in cycles by $\pi/_2 \times 4 = 2\pi$ instead of by 4 and obtain the maximum value of the induced voltage for any given maximum flux.

The induced voltage is in direct ratio to the inducing flux, and by using the factor 2π in preference to the multiplier 4, effective or average values of the flux may be taken and the voltage corresponding thereto will be expressed in effective or average values, as the case may be. In commercial work, the effective values are the only values of interest, consequently these values are generally used in all calculations.

Allow 20 per cent. increase in inductance for the inductance of the end rings. Alow for two bars per circuit. The total c.g.s. lines per ampere are:

$$.442 \times 1.20 \times 2 = 1.0608$$

The reactance of the circuit is the back e.m.f. induced by this flux and amounts to

$$\text{Back e.m.f.} = 1.0608 \times 2\pi\, 60 \times 10^{-8} \text{ volts.}$$
$$= .000004 \text{ volts.}$$

The leakage flux between the copper bar and the external diameter of the secondary has a path area ⅛ inch by 5 inches, and the average length of path is $^{11}/_{32}$ inch. Then the flux per ampere is 5.82 c.g.s. lines and the back e.m.f. is .000022 volts per bar.

Reluctance of air path only is considered here in figuring the reactance. Any results obtained are necessarily approximate. A result within 10 per cent. of actual value would be a close approximation, and such refinements

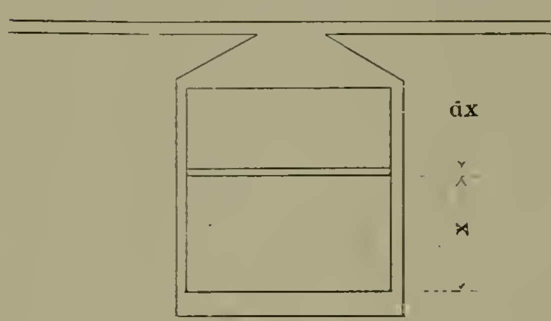


FIG. 3.

as making a calculation of the complete leakage flux through iron and air needlessly prolong the calculation without giving a more accurate result.

Two facts are brought to light, however, when the reluctance of the iron in the leakage path is considered. One is the immense amount of leakage around an entirely closed slot. If the space between the bar and the external circumference of the secondary be entirely filled with iron, the leakage at this point would be several hundred times the amount here found with the partially closed slot. The other fact is the necessity of guarding against high flux densities in the parts of the iron projecting over the slot. By making these projections thin and bringing the lips very close together, the flux density is raised to a point where the heating is serious.

The third and last path for leakage is through the bar itself. The reactance due to the flux through this path cannot be obtained without introducing the calculus. A cursory examination of any elementary calculus is all that is required to enable any one to make this calculation for himself or to follow that given below.

Dimensions as given in Fig. 2 are reproduced in Fig. 3, and the symbol x is introduced to show the points between which this dimension is taken.

The length of path is $^9/_{16}$ inches. The area of path for a flux dB at plane x is dx times 5 inches. The induction through the elementary area is produced by only that part of the total current flowing between the elementary area and the lower surface of the bar. Expressing the dimensions in centimeters, the height of the bar, ½ inch, is 1.27 cm.; the proportional part of the total current producing the flux dB is $\frac{x}{1.27}$. Substituting these values in the formula given above for m. m. f., length and area gives:

$$\frac{4\pi\frac{x}{1.27}}{10} = dB\frac{1.42}{12.7\,dx}$$

This reduces to

$$dB = 8.85\, x dx.$$

The leakage flux through the elementary area links with only $\frac{x}{1.27}$ of the bar

$$d\,(\text{back e.m.f.}) = 10^{-8} \times 2\pi\, 60 \times \frac{x}{1.27} \times 8.85\, xdx.$$
$$= .0000263\, x^2dx.$$

The value of x varies from zero to 1.27 cm.

$$\text{back e.m.f.} = \frac{.0000263}{3}\left(x^3\right)_0^{1.27}$$
$$= .000018 \text{ volts.}$$

The total back e.m.f. per ampere with the secondary at standstill on a 60-cycle circuit is equal to the sum of the voltages due to the flux in the three paths. The flux through the air gap was increased 20 per cent. to allow for the reactance of the end rings, and was multiplied by two for the two bars in the circuit. Similarly, the voltage due to the flux through the other two paths is increased 20 per cent., to allow for contingencies of manufacture and for the reactance of the end rings, and is multiplied by 2, giving a total value of .0001 volts.

With 1000 amperes in the secondary, the reactance volts are .1 volt at standstill and .01 volt at 10 per cent. slip. The reactance volts at 10 per cent. slip are 10 per cent. of those at standstill, because the frequency is 6 cycles per second instead of 60 cycles.

[TO BE CONTINUED.]

Parallel Operation of Direct-Current Generators

By J. C. HAIL

A GENERATOR operates at its maximum efficiency at or near full load. Therefore, when the total output of a station varies from hour to hour, as it always does in electric lighting and street railway service, it is desirable to use several generators, which may be put into service one after the other as the station output increases, and disconnected one after the other as the station output decreases, the object being to maintain nearly full load at all times upon the generators which are in service,

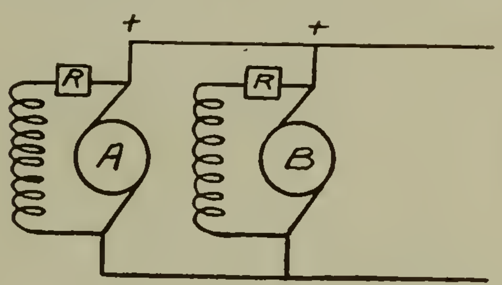


FIG. 1.

and thereby obtain the highest possible plant efficiency.

This is especially advisable when each generator is driven by a separate engine, since then the engines may also be operated under the most economical conditions. The use of a number of generator units in a plant is also advantageous in that a spare unit may be installed at a moderate cost to serve in case of a breakdown, whereas a single-unit station would have to be completely duplicated in order to provide for such an emergency. With several generators the plant will operate continuously, since if one generator is out of order a small reserve unit can be substituted at a moderate cost. This would not be the case if a single dynamo were operated for the entire load of the plant. This continuity of operation is very important since a shut down may cause great loss of trade and be the cause of much damage.

Generators of the shunt and compound types used for light, power and railway work are always operated in parallel. In this method of connection the *e. m. f.* of the circuit remains constant and the current capacities of the generators are added.

We shall first consider shunt-wound generators connected in parallel (Fig. 1). Both positive terminals are connected to one bus-bar and both negative terminals to the other bus-bar when the dynamos are in operation. If, as is usually the case, one generator is running and excited, care must be taken that it is not joined in parallel with a second machine while the latter is at rest or is unexcited. The armature of the second machine would then form a short circuit to the first and would present no *e. m. f.* opposing an excessive rush of current through its low resistance and both armatures would burn out. Hence the second machine *B* must be up to normal speed and generate the same voltage as *A* before it is thrown in parallel with *A*. Each machine will then, if both machines are similar, take half of the total current. If the speeds remain constant, the *e. m. f.'s* will be constant and each machine will constantly carry half of the load. Any inequality in the loads which may occur through any cause may be readily corrected by means of the field rheostats. For instance, a diminution in speed could be compensated for by in-

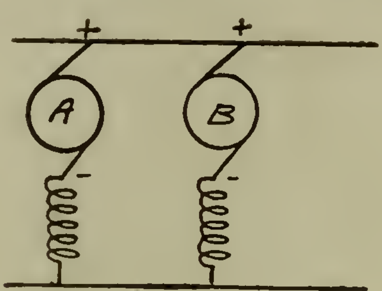


FIG. 2.

creasing the field current of that machine till the proper *e. m. f.* could be obtained.

Shunt dynamos tend to steady each other for, if one happens to run too fast, its *e. m. f.* being thereby increased, tends to increase the current developed by the armature; this increased current causes a decrease in pressure, due to an increased armature drop, reaction on the field and decrease in speed due to greater torque having to be overcome. Also, if one machine runs faster than another it takes part of the load off the other machine and tends to make it run faster, thereby raising the voltage and producing equality again. This mutual regulation will take care of any slip in the belt or governing action of driver. If the speed of one machine should for some reason become so low that its *e. m. f.* would be less than that of a second machine, it would have current supplied and run as a motor. This, apart from blowing out safety fuses, would not do any injury since the direction of rotation of a shunt generator is the same as that of a shunt motor.

We will now consider series machines run in parallel (Fig. 2). If two series generators, *A* and *B*, connected in parallel be started with a proper division of the load, and the speed of *A* decreases, causing its *e. m. f.* to decrease, the machine at once takes a smaller part of the total load and the current in its field is decreased. This in turn causes a further decrease in pressure and again there occurs a decrease in the load carried until finally the pressure falls so low that its field is reversed and it is converted into a motor. As a motor its direction of rotation is opposite to its direction of rotation as a generator and the result of the reversal may be very serious. Since *A's e. m. f.* is reversed both dynamos will be in series around their own internal resistances and would probably burn out.

To prevent this occurrence it is necessary to connect all the field windings in parallel with each other. This can be accomplished by connecting the armature ends of all the field coils as shown in Fig. 3. Such a connection is called an equalizing connection or equalizer. This equalizer has a very small resistance and it is evident the total current among the fields will be entirely independent of the output of any armature. This ar-

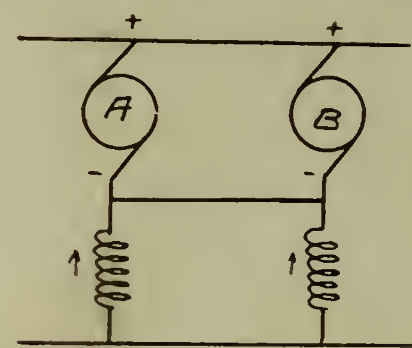


FIG. 3.

rangement of course requires the field windings to be attached to bus-bars of the same polarity.

By the equalizer the extremities of the two field windings are joined in parallel, and the current supplied to the external circuit flows in the same direction through both and magnetizes each equally. Should the *e. m. f.* of machine *A* (Fig. 3) fall below that of *B* a reverse current would pass through *A*, driving it as a motor, but as this motor current flows through the equalizer and does not pass in a reverse direction through the series winding of *A*, it does not change *A's* polarity. It is necessary to have the

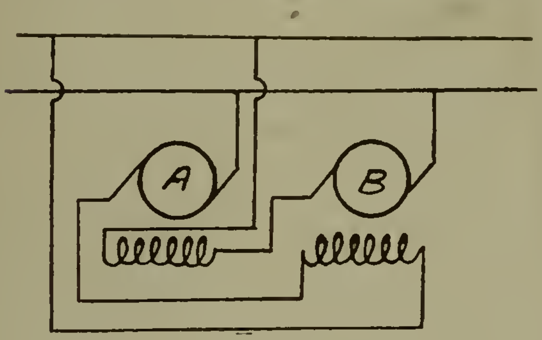


FIG. 4.

resistance of the equalizer very low or else a portion of the motor supply may pass through the coil of *B* into the field coil of *A*.

If it is required to switch *A* into parallel with *B*, which is running, it is necessary to bring *A* up to the same voltage as *B*. This is done by closing the equalizer circuit after both machines have normal speed. When the same voltage is obtained, throw machine *A* on the line.

When it is desired to operate two series dynamos of equal capacity in parallel, the equalizer may be dispensed with by connecting the fields so that each is excited by the other machine (Fig. 4). This is called "mutual excitation." In this case if the pressure of *A* falls, the load thereby decreases and the magnetization of *B* is reduced, compelling *A* to maintain its share of the load.

Series dynamos are, however, seldom worked in parallel, but the example aids us in understanding compound wound generators in parallel operation.

Since compound dynamos may be treated as shunt machines with the addition of series windings, it is evident that the requirements for connecting both shunt and series machines must be fulfilled when compound dynamos are run in parallel. Consequently an equalizer connection is used to cause proper division of the current among the series coils. When two compound dynamos of equal capacity are connected in parallel "mutual excitation" of the series fields may take the place of the equalizer. In the case of running compound generators in parallel let us consider what would happen without the equalizer. Consider two compound generators, *A* and *B*, in parallel as in Fig. 5. Suppose that machines are running steadily and that each is giving half of the total current that is being supplied to the mains. If machine *A* runs momentarily at a slightly increased speed, a momentary increase of its induced *e. m. f.* is produced, which causes an increase in the current which it delivers and a corresponding decrease in the current delivered by *B*. This is due to the fact that the two machines form together a closed circuit, and a slight difference in the *e. m. f.'s* of the two machine causes a large current to flow around this circuit, adding to the load of one machine and subtracting from the load current of the other. The increase of load current in machine *A* causes a further increase of the induced voltage in this machine, inasmuch as it is understood to be over-compounded, and this increase of *e. m. f.* causes a further increase of load current in *A*. At the same time the lessened current in *B* causes a decrease of its induced *e. m. f.*, which tends to decrease its current still more, and so on. This unequal distribution of load between *A* and *B* when once

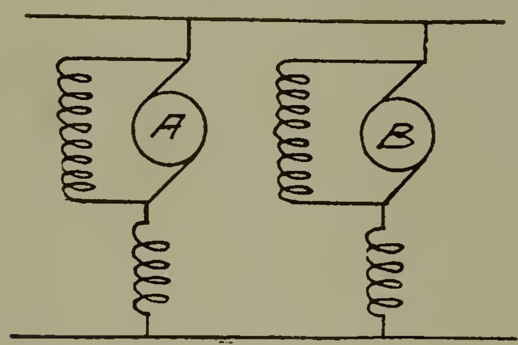


FIG. 5.

started goes on to an extreme and leads to an excessive current in machine *A* and a negative load current in *B*, that is, one machine will run as a motor and take power from the other.

With an equalizing connection, as in the case of series machines, the amount of current in the series coils is made the same if the drop over both coils is the same. The machines will divide their loads equally if both have the same capacity. As in the case of series machines, the resistance of the equalizer must be very low (practically negligible). The resistance of the series coils, together with the leads from thence to the point of common contact, must be the same, otherwise the current outputs will be inversely proportional to these resistances. If two machines of the same voltage but different capacities are to be worked in parallel with an equalizer, the resistance of the series coils must be inversely proportional to the outputs. If they have different values of compounding, the one that is most highly compounded must have its compounding reduced until they are approximately equal, else they will not properly divide the load and the compounding of the other machine may be injured by an excessive current. The over-compounding of one machine may be reduced by a removal of some of the series turns or by shunting it.

The method of operation is as follows in connecting compound wound generators in parallel (Fig. 6):

Suppose machine *A* is running, *B* is brought up to the same voltage, the excitation being furnished by the shunt field alone. The equalizer switch is then thrown to excite the series coil of the machine to be thrown in. The equalizer switch should be closed first, else conditions will be the same as if no equalizer were used; often the main switch is closed. The main switch is then closed and the load proportioned by means of field rheostats. To disconnect *B* when it is running adjust the field rheostats until all the load is on *A*, and disconnect *B* from the bus-bars. The equalizer switch is opened last, since if it were opened first it would be the same as having no equalizer bar.

It is a practice to sometimes keep the equalizer switch closed all the time, a permanent connection being made. This compounds the machines collectively instead of individually. For example, when only one dynamo is working, its current divides among the series coils of all and they will not be highly excited; when, however, all the dynamos are working the whole current of each will pass through its series coil. Thus the greatest field strength and, therefore, voltage is produced, when most needed at full load of all the machines. The method is important because it makes the effect of the series coil proportional to total load instead of load on each machine. This is desirable in central sta-

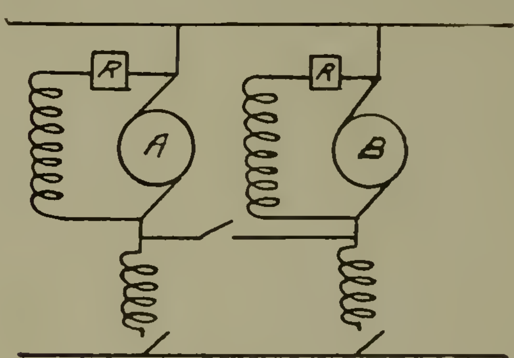


FIG. 6.

tions or where dynamos are over-compounded.

In case of over-compounded machines run in parallel the higher compounding is usually reduced by: (a) Shunting series field; (b) adding resistance to series leads; (c) reducing speed.

It has been found that shunting the series coils with a German silver shunt, while it is well enough in case of a single over-compounded dynamo, does not work very successfully when two or more dynamos are operated in parallel. They do not in any way aid the different dynamos in dividing their load. All the series coils and all the shunts become parallel conductors and thereby traversed by currents inversely proportional to their resistances. These shunts merely diminish the total flow of current, but in no way do they serve to adjust the effect of the series coils relatively to each other. Suppose two machines, *A* and *B*, are running, *A* is over-compounded and shunted, *B* is slightly over-compounded and slightly shunted. It is plain that when the shunted series coils are in parallel, the shunts will only have the effect of affording a path for a part of the total flow of current. An increasing load would be largely carried by the dynamo with the most turns on the series coil, because total current flowing through the series coil would promote the voltage of this dynamo faster than that of the other. Hence the best method is to either place a resistance in the series lead or reduce speed.

From the entire former discussion it is seen that two machines to perform best, when operated in parallel, should be designed so that they are exactly the same in construction and the same in their characteristics, that is, they should be identical machines.

If the compounding of one machine is greater than that of another, it should have its series coil adjusted so that its compounding is the same as that of the other machine with which it is run.

The drop over the series coils of both machines should be the same.

If the character of the magnets is such that the point of saturation differs for both machines, difficulty will be found to make machines divide load equally. Hence magnet cores should be of the same material in both cases.

Armature reaction may also be different for both machines, but this can usually be made similar for both machines by adjusting brushes.

The resistance of the equalizer should be very small so that current will flow through it rather than through the series coil of the machine.

Underground Conduit Systems for Power Work

THE use of armored cables having been practically discontinued for underground work in recent years, cables are now almost universally installed in conduits made

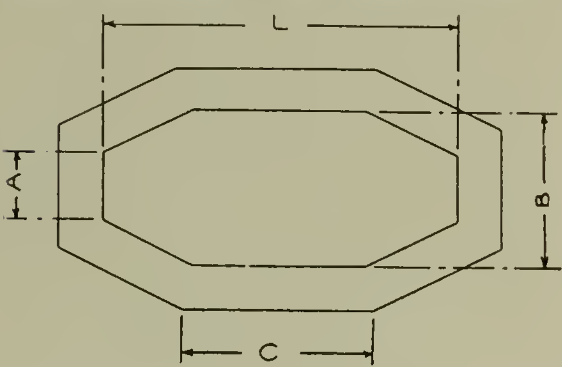


FIG. 1.

either of glazed tile, iron or paper fiber.

The pipes or conduits are laid so as to form a series of continuous ducts for a length of not over 400 feet, and are terminated in brick or concrete chambers, from which the cables are pulled in.

Fiber and iron conduits may be laid with greater rapidity and less labor than tile conduits, but are more expensive. Fiber conduit offers somewhat greater frictional resistance to the pulling of cables, especially on curves, and being mechanically weaker is not so suitable for great lengths.

SPACING OR SPLICING CHAMBER.

It is found that the greatest length of cable which can be pulled through a glazed tile duct without injuring the cable or requiring special apparatus is about 400 feet on a straight run or one with slight curvature. Hence, at distances of 400 feet along a duct line it is necessary to provide splicing chambers, where the separate lengths of cable may be pulled in and jointed.

Local conditions, such as obstructions and curves, may prevent the 400 feet being attained in all cases.

It is desirable to have no lengths greater than the standard length, in order to avoid the necessity of keeping extra long pieces of cable in stock.

DIMENSIONS OF SPLICING CHAMBERS.

The height of splicing chambers, being limited by the height in which a man can stand upright, is seldom less than 6½ feet. The width is similarly limited by the space required to work in, which is about 4 feet. The length is limited by the length of splice and the space required to curve the cable from the ducts to the supporting shelves or racks, considerations which make a length of 8 feet the practical minimum where there are large cables.

Special chambers, such as those for bare grounded cables, for a small number of telephone or other safe cables, may be made of smaller dimensions than stated above, because a man can work on his knees in a chamber 4 feet high and 3½ feet wide, and the length may be reduced to about 4 feet if the cables are small and flexible.

FORMS OF SPLICING CHAMBERS.

Splicing chambers are usually built in one of the four shapes shown in Figs. 1, 2, 3 and 4.

That shown in Fig. 1 is usually regarded as ideal, as the excavation is a minimum, and the cables can follow the walls very closely and may be clamped thereto where desired. A further advantage is the avoidance of the difficulty of bending cables to a dangerously small radius, a frequent occurrence in chambers with square corners.

The rectangular form shown in Fig. 2 is somewhat more common, but requires more excavation and more wall material than the first form, and is conducive to sharp bends in the cable.

The type shown in Fig. 3 is convenient where it is desired to have a wide chamber without occupying much space on one particular side of the duct line, as, for example, where

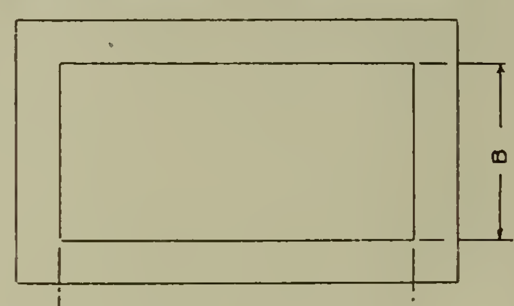


FIG. 2.

two duct lines run parallel a short distance apart. In this case, economy may be obtained by the use of a common wall on the long side of the chamber.

Fig. 4 shows the side wall type of chamber, which is entered from the side instead of the top, as with the other types. This form is used in the side walls of tunnels or in retaining walls, and usually takes the form of a long niche in the wall. When built in tunnel walls not far from the surface of the ground, it is desirable to have such chambers open from the street above as well as from the side, in order to avoid the necessity of having the use of a tunnel track when work is to be done in the chambers

GENERAL DIMENSIONS.

The following table gives the dimensions of standard splicing chambers used by several large traction and

Name of Company.	Fig. No.	A	B	C	Height Inside.	L	No. of Splices.	Remarks.
		Feet and inches.						
Chicago Edison Co.......	1	2′–3″	6′–0″	[3′–3″	6′–6″	7′–6″	16	....
District Ry. London....	3	2′–4″	5′–0″	5′–6″	7′–6″	14′–3	32	....
I. R. T. Subway, N. Y...	4	1′–3″	3′–0″	4′–4″	14′–0″	11′–4″	64	....
Long Island R.R........	3	1′–6″	4′–0″	2′–3″	6′–6″	10′–0″	18	....
" " "	2	—	4′–0″	—	6′–6″	9′–0″	18	....
" " "	1	1′–8″	4′–0″	3′–8″	6′–6″	9′–0″	18	....
Manhattan Ry. N. Y....	2	—	6′–0″	—	6′–6″	8′–0″	16 to 48	....
New York Central R.R..	1	2′–4″	5′–0″	3′–6″	6′–6″	11′–0″	20	....
"	3	2′–6″	5′–0″	3′–6″	6′–6″	11′–0″	20	....
"	3	1′–10″	4′–0″	3′–6″	6′–0″	10′–0″	5	....
"	4	1′–00″	3′–0″	3′–6″	6′–6″ to 8′–0″	8′–6″	20 to 32	....
Pennsylvania R.R.......	2	—	4′–0″	—	6′–4″	8′–0″	24	....
Philadelphia R. T........	3	1′–8″	3′–6″	corred	6′–3″	7′–10″	20	....

lighting companies. The letters refer to the dimensions on Figs. 1, 2, 3 and 4.

The average volume of a chamber is about 16 cubic feet per splice, although a maximum of 40 and minimum of 6 are sometimes found.

WATERPROOFING AND DRAINAGE.

There is great diversity of opinion with regard to the value of waterproofing splicing chambers, although

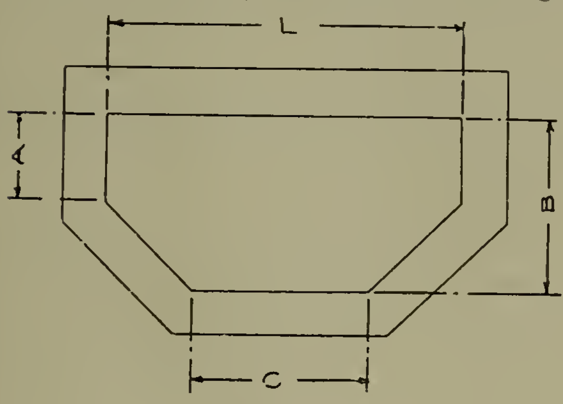


FIG. 3.

the general tendency of the day is to omit waterproofing and provide efficient draining.

Waterproofing a chamber is futile unless the duct lines leading to it are also waterproofed. This is a very difficult and expensive process which seldom shows good results. Water will also enter chambers from the top and will be retained if the chamber is waterproof.

Every chamber should be provided with a sump into which water can drain. It is advisable to connect the sump to the sewer through a syphon and back-water valve. If this is not practicable, the sump may be drained by a hand pump through the manhole opening.

Where natural drainage cannot be secured, as, for example, where the chamber is below sewer level, it is good practice to provide a special drain pipe to which all chambers are connected, the drainage being toward a general sump pit, which is kept dry by an automatic sump pump. The cost of such a system often compares favorably with that of waterproofing, besides yielding superior results.

The sump of a splicing chamber should be covered with an easily removable grating—wooden ones being often used on account of their property of floating when the chamber is flooded, thereby leaving the sump open for the pipe of a hand pump.

MANHOLE CASTINGS.

Usually made with two covers, the outer of which should be strong enough to stand the weight of the heaviest vehicle, and the inner should be as high as consistent with the rough usage they receive. Both covers should be provided with means to grip them with a hook-bar.

Where power cables are used it is essential to provide ventilating holes.

It is usual to lock the inner cover with a substantial brass padlock.

CABLE SUPPORTS.

Cables in splicing chambers are usually supported on iron brackets attached to the chamber walls. This construction is very satisfactory for many types of cables, but for power cables, especially direct-current feeders, a shelf of some kind is preferable, as it affords some insulation and protection between cables.

Concrete reinforced with expanded metal or wire cloth has proved satisfactory for shelves one inch thick, and is inexpensive. A good support for such shelves is a pair of iron pins set in iron pipes, which are sunk in the chamber wall at a slight angle, so as to tilt the shelves toward the wall, as shown in Fig. 6.

Shelves cannot be spaced less than 7 inches apart for large wrapped power cables, and therefore make it impossible to have as many cables in a chamber as when duplex racks are used. This, in fact, is the principal argument in favor of iron racks, for the brackets may be made to carry two or more cables each, as shown in Fig. 7.

Open face ducts constitute a type of shelf which may be conveniently run all the way through a chamber to connect duct to duct. This gives excellent protection to the cables, but owing to the large size of the open-face ducts, which must be large enough to accommodate a splice, the number of ducts which can be used in a moderate size chamber is very limited.

PROTECTION OF CABLES.

When a large direct-current feeder cable is punctured the current tends to take a short circuit to ground

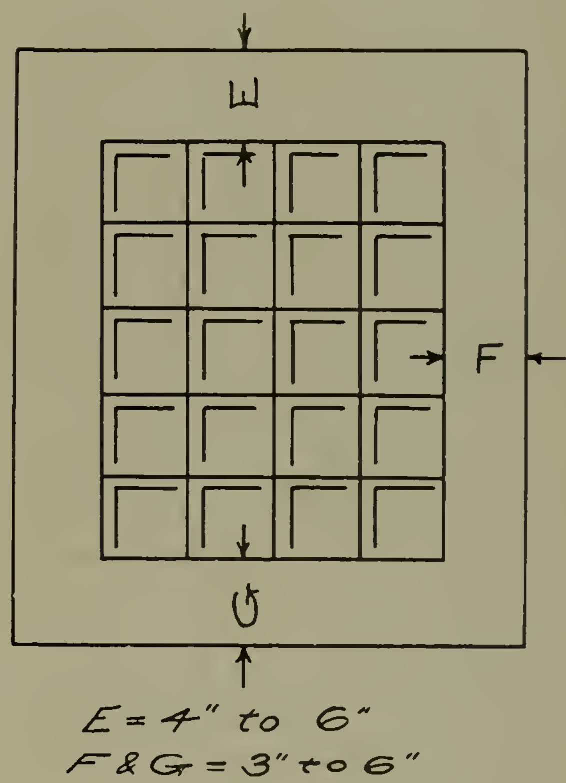


FIG. 5.

through the most available paths. If the cable is supported on an iron rack which is fastened to the same iron upright as other cables, the short circuit current will pass through the racks and uprights to other cable sheaths, which may be melted thereby. In order to avoid this it is usual to interpose a piece of rubber hose, a creosoted block, or equivalent insulating material, between each direct-current cable sheath and its rack.

It is current practice to protect all power cables in splicing chambers by a wrapping of asbestos cloth, fastened on with galvanized steel tape; some companies using over this a sheath of stove piping made fast with galvanized steel wire. This protection should extend all the way through the splicing chambers, covering the splices.

DIRECT-CURRENT CABLES.

The cables which give the greatest trouble in underground conduit lines are direct-current cables of large carrying capacity. The reasons for this are:

(1) When they are punctured the cable is short-circuited to the sheath, and the current is so great that the sheath is melted, often for a length of several hundred feet.

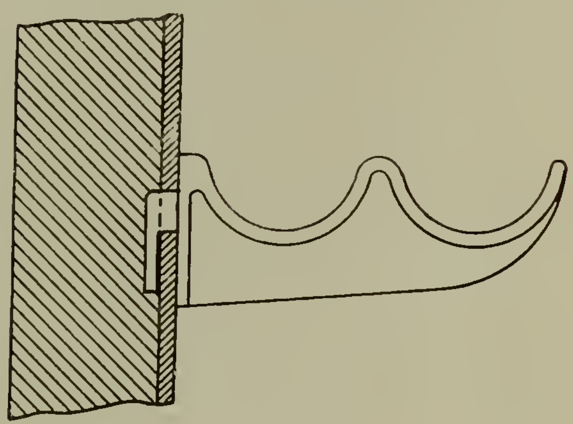


FIG. 6.

(2) If the direct-current cable sheath is in metallic connection with other sheaths, the short-circuit current will distribute itself among these sheaths, and may melt them in the same way as the sheath of the original cable.

(3) When cable sheaths are melted or burned, not only are the cables put out of use, but it is often impossible to withdraw them from the ducts, which therefore have to be broken into and replaced. If this does not occur, the lining of the ducts may be so roughened as to render new ones necessary.

(4) The arc established at the point of short-circuit is so intense as to be a source of danger to linemen, to other cables and to the structure of the splicing chamber itself.

(5) If the short-circuit occurs far from the station-bus, the resistance of the line may be sufficient to keep the value of the short-circuit current below that at which the circuit breakers are set to open. Such short-circuits are particularly dangerous because there is no way to distinguish them on the station meters from a regular load.

With these facts in view, the following precautions should be adopted with large direct-current cables:

(1) Where possible, keep the direct-current cables out of the duct lines which carry the alternating-current cables. It may be advisable to put the required conductivity in the third rails in order to avoid the necessity of auxiliary copper in duct lines along the track.

(2) If it is necessary to put direct- and alternating-current cables in the same duct line it is well to isolate the direct-current cables as much as possible in the splicing chambers. This may be effected by running them in open-face ducts, or by protecting them with split ducts put around the cables and held together by clay. Such ducts may be supported on one or two light angle irons extending longitudinally through the chamber.

(3) The racks on which direct-current cables are supported in splicing chambers should not be in metallic connection with other racks. If, however, this is unavoidable, the cables should not lay directly on the racks, but on insulating pads or blocks, as stated above.

(4) The electrostatic charges on the sheaths of low-tension cables are insignificant, and none can be derived from the high-tension cables if these are properly grounded. It is therefore unnecessary to ground the sheaths of direct-current cables of an insulating system. With a grounded return system, however, the case is different, for however well the cable sheath is insulated in a duct line, in the case of a short circuit the current will find its way through the most unexpected paths, thereby creating wide-

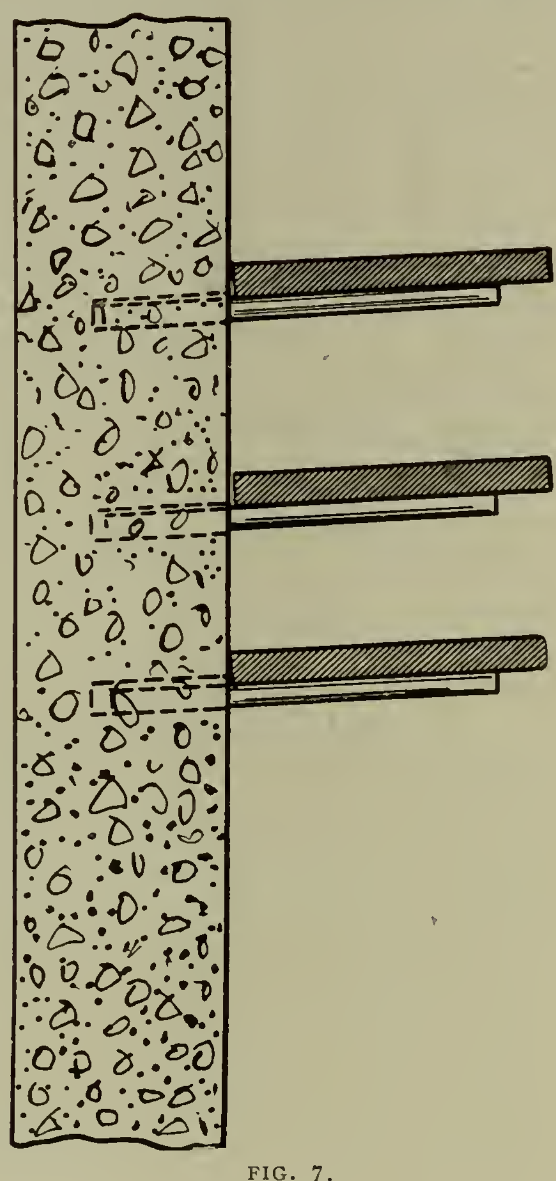


FIG. 7.

spread damage. As grounded return systems are used principally for railways, it is usual to ground the direct-current cable sheaths directly to the track rails through stout wires. Where this is done high-tension cables in the same subways should be grounded to earth plates. Railroad tracks having insulated sections for automatic block signals cannot be used in this way, as the sections would be electrically connected through the cable sheaths. In such cases the only practical way to deal with large direct-current feeders is to keep them out of the duct lines and carry them on insulators.

This is a simple matter where retaining walls or tunnel walls are available, as it is easy to support weatherproof cable on large porcelain clamp insulators attached to the walls. In the open, however, it is usually necessary to support the cables on insulators placed in a wooden or concrete trough, which is filled with viscous insulating and waterproof compound. This is known as the "solid system."

ALTERNATING-CURRENT CABLES.

Arcs produced by the rupture of alternating-current cables are less intense than those produced by direct-current cables, for the following reasons:

(1) The periodic reversal of the current tends to extinguish the arc twice in every cycle.

(2) The amperes per k.w. transmitted are less than with direct-currents, owing to the high voltages used in alternating-current transmission systems.

(3) The use of two or three conductor cables helps to make a clean short circuit, which will operate the power-house relays at once and thus open the circuit. It also does away with the tendency to follow any roundabout path to ground as with direct-current cables.

(4) The carrying capacity of the lead sheath of a high-tension cable is usually great enough to take without injury sufficient current to operate the relays in the power-station, especially where a resistance is used in the grounded neutral of the generators.

CHARGES ON CABLE SHEATHS.

When an electrically charged body is introduced, without touching, into a cylindrical conductor, a charge is induced on the inner surface of the cylinder, which is equal in magnitude but opposite in sign to the charge on the electrified body. If the cylinder is insulated from the earth there is also induced on its outer surface a charge of equal magnitude and similar sign to that of the electrified body. The difference of potentials between the charged body and cylinder depends on their dimensions and relative locations, and may be very considerable. If, however, the cylindrical conductor is connected to the ground by a metallic wire, it will be maintained at ground potential.

A high-tension cable in a lead sheath acts precisely like the charged body in a cylindrical conductor described above, inducing a charge on the sheath which may raise the latter to a dangerously high potential.

It is therefore necessary to ground the sheaths of cables at intervals, in order to carry off their static, as the induced charge is commonly called.

DOUBLE DUCT LINE.

A conduit line of a large number of ducts should be avoided wherever possible. While a large line may be permissible for telephone work, it certainly is not desirable for light or power work. The entire output of a station or substation of considerable size should not be carried out through one conduit line, but should be divided between two or more lines, kept well separated.

INSPECTION OF DUCTS.

By far the greatest number of cable breakdowns occur from injury to the lead sheaths, either by electrolysis or from abrasions during installation. Sharp projections in the ducts should therefore be carefully guarded against as a cable pulled over such a projection will have a groove cut along its entire length, and the effective thickness of the sheath will be thereby materially reduced. The duct specifications given below are typical of the best modern practice, but unfortunately duct inspection is usually so lax that often in a large installation scarcely a single duct conforms in every particular with the specifications. Engineers are now beginning to realize the enormous importance of giving each duct a rigid inspection, and rejecting those which have any roughness or irregularity.

Scarcely less important is rigid inspection during installation in order to assure the most perfect alignment.

SPECIFICATION FOR DUCT WORK.

1. Location of duct lines.

2. Description of ducts.

(*a*) Single way, or four way.

(*b*) Holes circular or square with rounded corners.

(*c*) Maximum outside dimensions.

(*d*) Minimum inside dimensions.

(*e*) Minimum thickness of walls.

(*f*) Shall be free from blisters, cracks and other imperfections which, in the opinion of the engineer, will tend to injure the cables to be accommodated therein.

(*g*) Shall be of good quality tile, thoroughly glazed inside and outside.

(*h*) Shall be straight and true.

(*i*) Shall be provided with holes for dowel pine if ducts are four-way. Dowel pins may also be called for.

(*j*) Ducts shall be of stated length. It is usual to call for a certain percentage of shorter lengths in order to finish runs or to stagger joints. The permissible variation from the specified length should be stated.

(3) Description of cement.

(*a*) Shall be of approved brand.

(*b*) Briquettes made of neat cement and kept one day in air and six days in water shall show a stated tensile strength. A corresponding strength may be similarly required of briquettes made of one part cement and two and one-half parts sand.

(c) Shall be protected from moisture during work.

(4) Description of sand.

(*a*) Shall be clean and free from loam or salt.

(*b*) Shall be sharp and of stated coarseness.

(5) Description of stone.

(*a*) Shall be of crushed granite, limestone, trap-rock, or other approved variety.

(*b*) Shall pass through a sieve of stated mesh.

(6) Description of brick.

(*a*) Shall be of good commercial hard-burned sewer brick, or other stated variety.

(7) Description of concrete.

(*a*) Stated proportions of cement, sand and stone.

(*b*) Sand and cement shall be mixed dry and then wet with only sufficient water to make a stiff paste. The stone, being previously wetted, shall be added while wet and thoroughly mixed until all the stone are covered with mortar. It shall then be deposited as rapidly as possible. Machine mixed concrete will be accepted if made in a manner approved by the engineer.

(8) Cement mortar.

(*a*) Stated proportions of cement and sand. (Usually 2½ of sand to 1 of cement.)

(9) Concrete or mortar shall not be laid in freezing weather, and shall not be used after an initial set has taken place.

(10) Excavation.

(*a*) Shall always be of such depth as to leave a stated minimum distance between the top of concrete over the ducts and the surface of the ground.

(*b*) Ground on which ducts are laid shall be rammed solid before any concrete is laid.

11. Refilling excavations.

(*a*) The best part of the material excavated shall be used.

(*b*) Surplus material shall be carted away by the contractor (or will be carted away by the company, as required).

(*c*) Filling shall be thoroughly tamped, rammed and rolled, or flushed as seems necessary to the engineer, and shall be done in a manner to prevent, as far as possible, a settling of the earth after completion.

12. Obstructions encountered in the course of the work shall be overcome in a manner to be approved by the engineer.

13. Laying ducts.

(*a*) Shall be laid evenly, with ends square, so as to leave a tight, well-fitting butt joint.

(*b*) Joints shall be staggered horizontally and vertically.

(*c*) Ducts shall be laid in a bed of cement mortar of about ¼-inch thickness.

(*d*) Each joint shall be wrapped with two strips of burlap 6 inches wide and coated with neat cement mortar, the ends of the wrap to lap 4 inches. (It will ensure more careful work if it be specified that the contractor shall supply rubber gloves to the men who lay the burlap.) Where ducts are laid on curves, the wraps shall be doubled if required to protect the openings between the ends of the ducts on the outer line of the duct, and to exclude mortar from said openings.

(*e*) Ducts shall be laid with a mandrel of specified length and width and provided at the end with a rubber washer for wiping the joints.

(*f*) Ducts shall be laid on a bed of concrete of stated depth, shall be covered at the top with a stated depth of concrete and shall have a stated thickness of concrete on each side. Where the duct line goes under railroad tracks, the concrete shall be suitably thickened and reinforced.

(*g*) If ducts are four-way, they shall be laid with dowel pins at joints.

(*h*) The alignment horizontally and vertically shall be satisfactory to the engineer.

(*i*) The method of wrapping specified in *e* is not universal. If another method is to be used, corresponding details should be given.

14. Drainage of duct lines.

The grade of all duct lines shall be such that water cannot stand in the ducts, and they shall be so arranged as to drain into one or both of the splicing chambers.

15. Rodding, cleaning and wiring.

After the ducts are laid and the cement is sufficiently set, they shall be rodded and the contractor shall draw after such rods, wire brushes and a mandrel of specified dimensions. All mortar and other foreign matter shall be removed. If obstructions are found which cannot be removed by cleaners, so as to pass the specified mandrel, the ducts shall be removed and relaid.

Any expense incurred by such work shall be borne by the contractor. A galvanized iron wire of stated size shall be left in each duct from splicing chamber to splicing chamber, and sufficient length shall be left at each end to permit it to be bent in order to prevent it slipping into the duct.

16. Repairing.

All repairing shall be done in a manner satisfactory to the engineer and the municipal authorities.

17. No extras shall be allowed the contractor for irregular work except,

(*a*) Rock blasting, if necessary.

(*b*) Removal of pipes or other obstructions, if necessary.

Such extra work shall not be done without the consent of the engineer. The contractor shall specify the cost of such work before it is begun.

18. Details of terminals of duct lines. (Whether they go into power stations, etc.)

19. Splicing chambers.

(*a*) Shall be built according to plans supplied, unless local conditions interfere, in which case the suggested modifications shall be approved by the engineer.

(*b*) Chambers to be not more than a stated distance apart.

(*c*) State any details pertaining to the design of the chamber and cable supports which may not be clear from the plans.

Institute Discussion on the Moore Light

IN opening the discussion on the paper on the Moore tube. read at the April meeting of the Institute, Gano S. Dunn, who presided, said that we should be careful not to make the mistake of estimating the value of the Moore system solely on the basis of efficiency. Its intensity does not vary inversely as the square of the distance. We must be careful not to take the test of the photometer as the only guide.

The test of the lamp should not be the test of the efficiency, but rather the test of the light it delivers where illumination is wanted. A light of high intrinsic brilliancy, of concentrated source, over-illuminates the surface near it, while it under-illuminates the surface away from it. The eye is also inclined to undervalue the illumination of the under-illuminated surface, because it often passes on this surface after having first rested on the bright surface, or possibly upon the lamp itself. Not only this, but the excess of light in the neighborhood of the over-illuminated surface costs money and has to be paid for; besides which that very excess, by having fatigued the eye, renders of less value the illumination we do actually succeed in producing upon the under-illuminated surface.

The feature of Mr. Moore's light is its distributing source, the enormously large area over which it illuminates, compared with the area of a nut-shell, in which other lights are generated, or of a short tube in which a Cooper-Hewitt mercury vapor light is generated. We must be on our guard in estimating this.

The chairman then called on Dr. Steinmetz, who characterized the paper as a valuable addition to our engineering knowledge of the method of producing light by what may be called an improved Geisler tube, because it is the old Geisler tube now in the form of a commercial illuminant.

The paper, said the speaker, gave the first actual engineering data of this kind of light, the actual energy, current and some data on efficiency, etc. Comparative data were given on the illumination produced by the Moore tube and the incandescent lamp. Later on, comparisons were made between the arc lamp and other systems. Dr. Steinmetz did not think much of the comparative value, the relative proportions between the two, except that it showed that we can install incandescent lamps and arc lamps in such a manner as to get very little light from very much power. We know that if the installation of the incandescent lamp is left to the artistic sense of an architect, or to mere accident, we will get this condition, but the comparison is not fair, because if we replace an unsatisfactory incandescent light system, unsatisfactory by reason of poor installation, poor size of reflector, etc., with an intelligently installed system, we can naturally always show advantages.

The results of the photometric tests in the paper give for the most efficient tube 1.4 watts per Hefner foot, which would be at right angles to the tube. The average light in the reading is twice this. The efficiency of the upper sum, divided by 1.88, to reduce it our standard of light, the British candle, gives 2.5 watts per mean spherical candle-power or per lumen, per unit flux of light, 2.5 watts. That test of the illumination measurements gave us 2.56, so that it makes it probable that the efficiency of light production, leaving out all illuminating questions, merely considering, as we always have to consider, whatever may be said, the question how much flux of light we get per watt, and the next

In illuminating questions we must consider how much flux of light we get per watt, and next whether we want to distribute the light and how it can be done. The first question is how much light comes from the source of light, and the best efficiency seems to be about 2.5 watts per unit flux of light, that is, per lumen. That flux of light is given by one mean spherical candle. That gives us about the efficiency of the tantalum lamp, or not very far from the enclosed arc; better than the incandescent lamp, the carbon incandescent lamp, but inferior to the tungsten lamp. The carbon dioxide tube is recognized as less efficient. The efficiency of the Moore tube has arrived at that stage where it is now in the range of commercially practical efficiency as an illuminant. It is not any more an inefficient illuminant, although it is not of the same magnitude of efficient, as, for instance, the mercury lamp.

But this efficiency of light production is not the only thing. The essential question is: How can we make use of this light, in other words, the distribution? A very great essential is low intrinsic brilliancy to eliminate the dazzling effect and blinding glare, which applies to the new source of light, the tungsten filament, for instance, which is rather bad. We must, however, not attribute too much importance to this feature, because even a point source of light can be diffused by a defracting or diffusing globe, holophane or frosted globe. Light is lost by it; but if we take a 32-candle-power tungsten lamp, and enclose it in a frosted globe three to four inches in diameter, we bring the intrinsic brilliancy of the whole globe down to five Hefners per square inch and probably less—from 15 to 20 per cent. of efficiency—and still have an efficiency higher than the Moore light.

Reference is made to the blinding brilliancy of the mercury tube. The speaker had not noticed that. He was using the mercury tube almost exclusively as artificial illumination for any work that he might have to do, and would not think of using any other source of light, and found it by far the best.

Dr. Steinmetz challenged the statement that, "The only commercial and proper method of comparing all sources of light is on the basis of their ability to produce useful illumination, and not by any other basis." It was a good way where one has a contract with a customer to light his premises, but that does not help one step further. The customer wants to find out how he can get good illumination with an economical amount of power, and if the illuminating engineer puts in the lights the important question is, what type of light to employ to use the least amount of power to produce illumination? For the illuminating engineer the most important question is, what source of light gives the maximum flux of light for a given amount of energy; the maximum quantity of light per watt? The next question is, whether this source of light is suitable for distribution, and how much of the light he may have to waste to get the proper distribution. But the statement quoted is rather begging the whole question of illuminating engineering. It may not be desirable for the customer, but for the illuminating engineer the question is how to get the light efficiency and how to supply the light with the least amount of power to the customer.

In determining the efficiency of illuminants, to find out which illuminant requires the least energy to give a certain illumination in such area, Dr. Steinmetz believes we would find first the mercury lamp, and then for a long while nothing; and then the tungsten, and then for a long while nothing; and then the Moore light, the tantalum and the enclosed arc, and later on the different filaments and incandescent lamps and carbon lamps and Nernst lamps, etc. After all, neither the Moore light nor the incandescent light has the same magnitude of efficiency as the mercury vapor lamp.

While criticizing the character of the paper, we must not forget that it contains some very valuable and important information, and Mr. Moore was to be congratulated on the great advances he had made in the last few years, in reaching commercial conditions with his light, reaching commercial frequencies, commercial voltage. One thing which had not been especially dwelt on, was the remarkably ingenious valve arrangement of feeding air or gases into the tube and maintaining a constant vacuum. The vacuum in this tube is about 1/8000 of atmospheric pressure. To maintain constant such a low pressure, not visible any more in a mercury gauge, and maintain that constant with a few per cent, was a very remarkable achievement.

Dr. Steinmetz appreciated very much also the very ingenious way of feeding the gas into the tubes, and the method of getting rid of the oxygen in the air, and feeding nitrogen or carbon dioxyde. These were remarkable and ingenious devices which could only be admired.

The next speaker, Percy H. Thomas, said that in addition to supplying a new candidate among the illuminants for commercial favor, Mr. Moore had done a good deal to educate illuminating engineers to consider the importance of diffusion and distribution in lighting, and the importance of eliminating bright spots.

His general discussion had a good many good points in it. There are a good many points, too, to which we might object. We can take the paper as a suggestion and forget those things with which we do not agree. There is one point which a great many people do not realize the value of, which Mr. Moore mentioned casually, and that is, if you can do your lighting in a room from one outlet and do away with the pendants and fixtures and small outlets, you save not only a great deal of expense but a good deal of fire risk and danger. The elimination of the cost of multiple outlets and many units, fuses, cords, etc., is one of the biggest factors of economy in Mr. Moore's tube over incandescent lamps, and the Cooper-Hewitt tubes over incandescent lamps.

Mr. Moore made a great point of the fact that he considers his tube to give artificial daylight. This statement needs a little challenging in the first place; daylight gives practically a continuous spectrum. Mr. Moore's light comes from gases and must be a banded spectrum—a few colors well distributed over the spectrum—which cannot give the same effect as a true continuous spectrum. How important this matter is will only be determined if we get a sufficient number of commercial installations and some considerable length of trial.

The tube does not give a strictly perfect diffusion, though at first sight it may seem that this is the fact. Our surfaces are plane surfaces and have two dimensions, but the tube has only one dimension. The diffusion is perfect in one plane and very imperfect in the other plane. In one plane the light is diffused and in the other plane, crosswise, the light is not diffused. It is even possible, with incandescent lamps distributed over the ceiling, to get a more perfect diffusion than with the tube. The short interruptions within the length of the tube are not as important in disturbing uniform distribution as a large gap from one side to the other. Perfect uniformity of light is not needed to give substantially uniform distribution.

There were a few more statements that perhaps required challenging. Mr. Moore stated, "It is now possible to state definitely what their final life will be, beyond the general statement that some of these tubes have already been in operation over 4000 hours without change, and that there are good reasons for believing that they should continue to run at least as long again, which is a much longer life than any other form of illuminant yet invented." Commercial Cooper-Hewitt tubes have operated for 10,000 hours in a great many places. On one or two instances they had operated for 16,000 hours. As to the statement, "It is the blinding brilliancy of the mercury tube that makes even a direct glance at it so very harmful to the eye," Mr. Thomas said it was a fact, so universally recognized among those who have worked under the mercury light or who know by practical experience with such lights, that this light is surprisingly restful and helpful for doing work under it.

To make a rough summary, it was a little too soon to tell what the commercial field of the Moore tube will be. Undoubtedly there is a field for such a light. Its good points are its relatively good efficiency, not the best, but relatively good, probably better than most incandescent lamps, its diffusion, and the fact that it has no bright, brilliant spots. The chief difficulties, the speaker thought, would be found to be a certain tendency to fail at times; for instance, this particular tube is entirely dependent on each particular part of the tube; any crack or damage done to the tube will affect the whole tube. It is not a matter of taking a spare out of the closet and putting it up.

The power factor seems to be a variable question. It was formerly 50 per cent. Now Mr. Moore has it up to 60 or 65 and expects to get it higher still. If the power factor is made very high it means the elimination, to a certain extent, of the resistance of inductance which absorbs voltage and will allow more variation in the current. That may become a serious factor.

The power factor is in some cases very important. Where power is bought from a lighting company and the power paid for by meter, it is not serious, because the drop in wiring comes in; but if the plant is a private one the capacity of the generator must be considerably greater for a lower power factor to get a given quantity of energy than with the higher power factor, and this would be an added charge against the Moore tube in cases where the load was exclusively for lighting these tubes.

With the whole illumination in the room dependent on one or two or three outfits, it it impossible to use a portion at one time. If in a factory two men are working in a corner, you cannot light that corner only, and you must perhaps use ten or twenty times as much energy as otherwise would be required. This cannot be urged against the tube in all places. It simply shows a certain limitation when considering the broad field.

Mr. Thomas thought Mr. Moore deserved a great deal of praise for the extreme pains and expense he had gone to to make his demonstration thorough.

Dr. C. H. Sharp thought that all admired very greatly the persistency of purpose and the courage with which Mr. Moore had tackled and had kept tackling for ten or fifteen years this great problem of the production of artificial light by the incandescence or luminescence of gases. Certainly the goal toward which he was striving, and the end which he sought to reach, was a most tempting one. We had all heard a great deal about the low efficiency of all of our ordinary illuminants. Very few of them approach five per cent. luminous efficiency. Some of them may reach the value of 10 per cent possibly, but most of them are perhaps of two or three per cent. luminous efficiency. It certainly was a very attractive problem, that of producing a really high-efficiency illuminant, and an illuminant working at a luminous efficiency, say of 90 per cent. instead of 5 per cent. It was to be sincerely regretted that as far as the present indication goes, in his endeavor to reach this high goal, Mr. Moore had failed. He had, however, succeeded in producing a practical illuminant which will undoubtedly find a field for itself in certain applications and which has an efficiency which brings it on a par with many of the other illuminants of the present day.

If we examine the data given, we get some idea of the efficiency. Dr. Steinmetz had gone into this question, and the speaker had gone into it from a slightly different point of view. Mr. Moore made a statement that the watts per Hefner of the yellow tube vary from 1.3 to 2.5 watts per Hefner candle; or, in other words, from 1.5 to 2.9 watts per candle measured at right angles to the tube. The white tube—the carbon dioxyde tube—has less efficiency. No data are given on the efficiency of this tube. However, we may arrive at a value by noting that the white efficiency bears a ratio to the yellow efficiency of 1.5 to 2.9, or about 1 to 2. In other words, the yellow tube is about twice as efficient as the white tube.

Taking this comparison, we find the watts per candle of the white tube would range from 3 to 5.8. The yellow tube, according to this, shows an efficiency over the carbon filament lamp. Its gain in efficiency is by no means revolutionary. There is a certain gain. The efficiency, however, according to this showing, is considerably less than that of the tungsten lamp. Consequently we can say, in a general way, that the Moore light does not represent an essential gain as compared with the other illuminants for the present time.

If, therefore, it is to find a place as a practical illuminant it must show certain other advantages which the illuminants with which it competes do not possess. Let us consider what some of these advantages are. It gives a diffused light; that is perfectly true. It is a light of low intrinsic brilliancy; it has no bright spots to blind the eye. It does away with a certain amount of wiring in the building. As far as this goes it is an advantage for the Moore tube. What are some of the disadvantages?

The speaker thought some might say that the color of it was not all that it might be. It may be the color of daylight, but it is a peculiar kind of daylight. It had the great disadvantage of not being divisible. By throwing a switch all the light in a room is turned on. We cannot have a little light here or there, as we need it. That point was brought out by Mr. Thomas. This indivisibility of the Moore light made it necessary, it seemed to the speaker, in all or nearly all of the installations where it is used to supplement it by some other system of light which had this feature of divisibility. It would hardly do to place all the reliance for the lighting of a room of any importance whatever on a tube of this kind.

Another disadvantage was the flickering on alternating-current. It is exclusively an alternating-current lamp at the present time, and when it is used on alternating-current of commercial frequency, we notice a very marked flickering of objects moved quickly in the light. In cases where the objects have to be handled with rapidity this would be a serious practical disadvantage. In any room where the objects are moved rapidly the effect which is produced could be scarcely called anything less than weird, and unless it is possible to overcome this disadvantage in some practical way, and it is hard to see how this is possible. We must mark this down as a serious detriment to this style of lighting. Another result of the indivisibility of the lighting is its inapplicability to localized lighting. Diffused and distributed lighting is excellent for many purposes, but we do not want it for all purposes. For, where localized lighting is desired rather than distributed lighting, in cases where lighting of high economy is desired rather than lighting which takes in all the area, we must use something which is capable of division, and the Moore tube would appear to be ruled out in this connection.

John W. Howell said it had been his pleasure to know Mr. Moore and to know his work during the entire 12 years he had been working on the vacuum tube. At first he showed a small Geisler tube, and for a long time afterward it was a simple Geisler tube, and when everybody thought that Mr. Moore was chasing rainbows he stuck to his work with a persistence and enthusiasm which the speaker had never seen equalled. The present light is a development from the Geisler tube, which it is hard to realize, because it has been accomplished by this most persistent work, the progress having been made little by little, step by step, never any very long steps until very lately. Mr. Moore has added a commercial illuminant to those which the electrical engineer has at his disposal, and one which has a good many uses in which it excels others.

Mr. Howell wished to congratulate Mr. Moore on his work. Among the uses to which Mr. Moore applies his light the first named is art halls. There are many art galleries which are open only during daylight hours because there is no illuminant safe enough to be entrusted in those art halls. The speaker thought the Moore light would be admirable for such work, because there was no possible danger in using it except, possibly, in installing it. If this light could be once installed the public could have the use of the galleries for much longer hours and with perfect safety.

Mr. Dunn said that he felt very much in sympathy with what Mr. Howell had said about the work of Mr. Moore. It had been an example of persistence that has seldom been exhibited before. He was not forgetting, in looking backward upon Mr. Moore's work, how very different the outlook was when, in years gone, we all looked forward to the day when we should have cold light. The speaker was Mr. Tesla's assistant at the famous lecture where he tried to secure cold light at extremely high frequencies. If he might venture to comment on some of the previous criticisms, particularly the one relating to the measurement of this light with a photometer and according to the old standards, the speaker would say that we have a right to take a practical man's view. In the room preliminary tests made in the afternoon showed that it takes 10 kilowatts to illuminate with the lights behind the cove; 5 kilowatts with the naked lights strung around the border, and 5 kilowatts to illuminate with the tube, and all could see that the tube gave a brighter light than either of the others. That was a practical fact that no discussion of photometry or brilliancy or efficiency could do away with. We should give Mr. Moore credit for having accomplished that.

In concluding the discussion, Mr. Moore said that practically all of Mr. Steinmetz's criticism was answered in the paper. One thing that would not be found in the paper was a discussion of the illuminating engineers who installed the other systems of lighting which were compared with the tube. The highest talent in the country was procured for the lighting of the hall and the lighting was done well in all respects. The same could be said in reference to the arc lamps that were compared with the tube. The paper showed the location of these arc lamps, and Mr. Moore was sure that the majority of illuminating engineers would agree that it would be a very difficult problem to locate these arc lamps in any more desirable or advantageous position than they were located in the basement, which was supplanted by the tube. So, also, with the location of the incandescent lamps in the lobby of the well-known theater, which is one of the tests referred to. These lamps were installed in the regular orthodox fashion for installing incandescent lamps in long rows, which is the best that can be done.

As to imitating daylight, no form of light will probably imitate it absolutely, but it should be our endeavor to imitate it as closely as we possibly can. It happens that with simple carbon dioxid, spectroscope analysis shows that the light comes closer to the imitation of daylight color values than any other form of light. It is in a class by itself. The most delicate shades of colors have been matched under the tube when it is producing a pure white light. It was not to be found fault with if the white light is more expensive than the yellow light; it was due to the laws of nature; it required more energy to develop the necessary wave lengths of white light, and for a spectrum that closely corresponded with daylight than it does to produce yellow light, and one that has a maximum effect upon the human eye.

The length of life of the tube had been referred to. He had said 8000 hours would be longer than any other form of illuminant, referring to commercial forms of illuminants, and then also to have the illuminant in perfect condition at the end of the test. It is true that some mercury tubes have had longer life, but at anything like the end of 10,000 hours run the mercury tubes are not clean. The Moore tube would remain at the same degree of transparency for an indefinite period of time. The statement about the brilliancy of the mercury light was careful. A direct glance at the mercury tube, judging by personal experience, was harmful to the eye. The mercury tube was a wonderful apparatus, and the work done by Mr. Peter Cooper-Hewitt on that line was to be admired by the whole scientific world.

The matter of breakage had also been mentioned. In all matters of energy it was well to have duplicate units, and therefore large areas are now provided for by equipping a number of tubes, so that the absence of light from one tube will be comparable to the going out of an arc lamp or several arc lamps. The best answer to the opinion on the matter of power factor was the cold fact that the tube in the room was operating at that moment at 75 per cent. power factor. Dr. Sharp and Dr. Steinmetz referred to the matter of efficiency, and also spoke of spherical candle-powers and a few other things. The curves merely showed the watts per Hefner, and he preferred the Hefner, having had years of practical experience in trying to use other so-called standards of light. If he remembered rightly, the committee of the Institute recommended the use of this word as the best standard. The matter of images was also referred to—moving objects. It was true that a higher frequency was not advantageous in a tube of this kind; years had been spent trying to get methods of overcoming it, without success. It was found when the tubes were put on the market that it was not an important problem at all, and of the two miles of tubes in use there was not a single practical commercial objection raised on this question. Even in machine shops, where the moving of the lathe and the matter of images would be of greater importance, this matter has turned out to be negligible. On frequencies higher than 60 cycles per minute the general trouble disappears entirely so far as the average eye is concerned.

In reference to the tests proposed in a room 40 x 80 feet he believed that it was the practical solution of obtaining a true commercial relative value of various forms of light. He stated that local tests must be stated in every test of that kind, but of course he was assuming local conditions to remain constant.

He believed it the duty of all electrical organizations to aid in every way possible to standardize all forms of light, and did not think this could be accomplished until a room such as he had described had been equipped.

Reference had been made to art galleries. He would merely add that in order to grasp the spirit of a painting it should always be viewed under the same quality of light it was executed under, namely, daylight. Therefore, the picture should be viewed in the closest imitation of daylight possible, and this can be done by plain carbon dioxide.

As to the color problem and its effect on the human eye, the paper also answered that question, that the light that comes nearest to the natural light is the one that is best. The nearer we approach to daylight the further away we shall be from doing injury to the eye. There are three factors of importance in connection with injury to the eye so far as light is concerned: color, intensity and steadiness. The object is to generate a light at such a low intensity that it is in a condition to be used in its initiative condition and final condition without any further change. The incandescent lamp or any of the point sources of light need shades either to soften the light or to reflect it, or diffuse it or tone down its color. With this method we can decide before we make the lamp just what color we need, and mix our colors in the gases and have the light of any particular quality which we desire for any special purpose.

Lightning Phenomena in Electric Circuits

THERE will be found woven through the paper submitted by Dr. C. P. Steinmetz at the March meeting of the American Institute of Electrical Engineers a very clear and logical classification of lightning phenomena, beginning with the definition:

In its most general meaning, as understood now when dealing with electric circuits and their protection, *lightning denotes all phenomena of abnormal voltage and abnormal frequency.*

The lightning phenomena in electric circuits then comprise:

External lightning due to atmospheric electricity.

Internal lightning due to defects of the circuit or its operation, etc., and

Surges depending for their energy on the power of the generator system.

The phenomena of abnormal voltage and frequency in electric circuits are the same three classes of phenomena met with in the disturbances in any medium which is the seat of energy:

1. Steady stress or gradual electric charge.
2. Impulse or traveling wave.
3. Standing wave or oscillation and surge.

Electric Charge. The pressure of the total electric circuit may gradually rise by an electric charge accumulating in the circuit.

Some causes of such steady and gradual accumulation of electric charge, and of potential difference against ground, of an electric circuit, are:

a. Collection of static charge from rain, or snow-drift, or from fog, carried by the wind across the line.

b. Electrostatic induction from a passing cloud.

c. Potential differences between line and ground due to differences of atmospheric potential in different regions traversed by the line.

d. Accidental electrostatic charges entering the circuit, as friction electricity from the belt of belt-driven machines.

Somewhat similar phenomena result from:

c. Unsymmetrical conditions of the generator potential: For instance, if in a three-phase system one line is grounded, with the three-phase voltage e between the lines and $\frac{e}{\sqrt{3}}$ between lines and neutral, the mean potential of the total system is that of the neutral point *A*.

f. Existence of higher harmonics in the electromotive force wave of a polyphase system, *of such order that they coincide in the different phases.*

The danger of such accumulations of potential lies:

a. In their liability to damage the insulation of the system by puncture, and

b. In their liability of producing, by their discharge, other and more serious disturbances.

The effects of steady electrostatic stress, whether unidirectional, *a* to *d*, or alternating as *c* and *f*, appear not only in its own circuit, but also in circuits in inductive relation thereto, and may even be more serious in secondary circuits.

Impulse and Traveling Wave.

The second class of phenomena is the impulse or traveling wave. A sudden local electrostatic charge of a transmission line, as by a lightning stroke, or inductively by a lightning flash suddenly discharging a cloud, or any other sudden local change produces a wave of potential and of current which runs along the line.

When reaching the station—generating or substation—such a traveling wave is partly reflected by inductance of reactive coils, transformers, instruments, etc., partly transmitted.

Some of the causes of such traveling waves are:

a. Direct or secondary lightning strokes entering the transmission line. This usually gives a single impulse, or very few impulses of extreme steepness of wave front.

b. Electrostatic induction by the clouds. Every lightning flash in the cloud, and between cloud and ground, requires a rearrangement of the electrostatic charge on the section of the line below the cloud.

Traveling waves resulting from this electrostatic induction are usually of lesser voltage.

They travel considerable distances, and probably are the most common manifestation of atmospheric electricity in electric circuits.

Through the electrostatic capacity between primary and secondary of transformers, these impulses frequently enter secondary circuits at an intensity increased by partial reflection at the transformer, and may even lead to sparks jumping from secondary wires to ground, as gas and water pipes, thus constituting a certain fire-risk, which can be completely eliminated by permanently grounding the secondary circuit.

c. Discharges of slowly accumulated potential, resulting in a series of successive impulses.

d. Any spark discharge from the line.

c. An arcing ground on one phase of an insulated system, or in general the existence of a "self-rupturing arc" in the system.

f. Sudden changes of load, connection and disconnection of apparatus, etc.

Standing waves, oscillations and surges.

In water, standing waves are less frequent and prominent, appearing in general only as stationary ripples in small pools. They form when a wave-train is reflected and thrown back by an obstruction, and the returning wave and the incoming wave. The standing wave is produced by the superposition of the impulse wave and its reflected wave.

In general, an oscillation of a transmission line is a complex wave, containing fundamental and higher harmonics.

A transmission line has not only one frequency of oscillation, as a combination of condenser and separate inductance, but an infinite number of frequencies, of which one is the lowest or fundamental, the others its odd multiples or higher harmonics.

These frequencies depend on the resistance, inductance and capacity of the line. Neither of these quantities is entirely constant.

A line for very high frequencies can oscillate at any frequency whatever.

The oscillation is the phenomenon by which in an electric circuit after a disturbance of the circuit conditions the flow of power restores its equilibrium.

Any circuit disturbance may contain only the very high-frequency harmonics, if the disturbance is local; but it may become universal by including the fundamental and the lower harmonics. In the latter case it is usually called "surge."

The power which oscillates is the generated power of the circuit; hence the possible destructiveness of the oscillation is limited only by the available power of the generating system.

The shorter the section of line which oscillates the higher is the frequency of the oscillation. The smaller, however, is also the power and the destructiveness of the oscillation, and considerable damage results, therefore only from low-frequency oscillations; that is, oscillations of the whole or a large part of the system.

Local high-frequency oscillations are dangerous chiefly by their liability to destroy insulation by puncture, and to produce a low-frequency surge of higher power.

Some typical forms of oscillations are:

a. Spark discharges to and from the line, as over some lightning-arresters; the breaking up of a traveling wave when entering the station, etc., result in the formation of very high-frequency oscillations, millions of cycles per second.

b. Arcing grounds and other arc discharges to ground from a line of an insulated system; reflected traveling waves, etc., give oscillations which, while still of very high frequency, reach considerably further down in frequency than *a*, hundred thousands of cycles per second.

c. Charge and discharge of the line, as when discharging an accumulated electric charge over a path of low resistance; connecting a dead transformer into the circuit, etc., results in high-frequency oscillations containing also an appreciable low-frequency component.

d. In general, changes of circuit conditions, as sudden changes of load; connecting or disconnecting a transmission line; opening a short circuit suddenly, etc., give oscillations in which the fundamental frequency predominates.

e. Low-frequency surges, consisting primarily of the fundamental wave, may be produced by certain transformer connections in polyphase systems, in which in case of an accident, an unequal distribution of load, or other causes, the open circuit inductance of a transformer coil is in series with the line capacity, in the circuit of a live transformer.

The problem of lightning protection then is threefold.

1. To guard against the entrance or origin of disturbances.

2. To guard against a disturbance leading to other disturbances.

3. To discharge a disturbance harmlessly:

The most important problems of lightning protection are met and should be solved before the question of lightning arresters is approached.

Estimating Line Loss as a Basis of Current Charge

ELSEWHERE in this issue is briefly told the experience of a central station in contracting to supply electric energy to the amount of 400 horse-power to a rolling mill two and one-half miles distant. In the following are given the steps in the calculation by which a proper basis for charging for current might have been obtained had a competent engineer been employed.

To again state the facts: The power company undertook to deliver 400 horse-power, in direct current at 220 volts, to the mill, and to do so put in a 500,000 C. M. cable transmission line. After completing the work, it was found that the voltage at the mill was less than 100. The 500,000 C. M. cables were accordingly replaced by 600,000 C. M. cables, the voltage then obtained at the motors being 160 volts. To bring the voltage up further a $10,000 storage battery equipment was installed.

Taking as a basis the 160 volts delivered, with 220 volts at the generator, a line loss is obtained of 7½ per cent., requiring a 520,000 C. M. cable; allowing for improperly made joints, sag of cable, etc., the size is increased to 600,000 C. M., about that necessary.

Assuming the mill equipment to be made up of one 150 H. P. and two 100 H. P. motors and 50 H. P. in smaller motors for machine shop work, it is likely that the $10,000 covers the cost of installing a booster to obtain the necessary 220 volts and a storage battery in parallel to keep down the energy required during peak loads.

On these assumptions, the cost of the present installation would be as follows:

5 mi. 500,000 CM. cable (bare) at 25c. per lb.	$10,250
5 mi. 600,000 CM. cable (bare) at 25c. per lb.	12,400
135 poles complete with cross arms at $12 each	1,620
Erection of pole line at $3 per pole	4,056
Erection of transmission line (5 men, 2 weeks at $20 per day total). App.	300
Duplicate of last item using 600,000 CM. cable	400
Allowance for tearing down first line	200
Addition of Storage Battery Outfit	10,000
Total	$35,575
Deducting scrap value of 500,000 CM. cable	8,000
	$27,575

The cost of the direct current transmission, with the present plant, is thus seen to be about $28,000.

It will be interesting now to consider the cost of a three-phase alternating current transmission at 2200 volts. This would entail a line of No. 000 bare copper wire strung on poles as in the direct-current plan, and at the rolling mill a motor-generator set consisting of a high-resistance secondary 2100-volt induction motor of approximately 400 H. P., connected to a 250-volt, direct-current generator of 300 k.w., mounted on the same bed plate, and between the motor and generator would be a cast or laminated steel fly-wheel of 10 or 15 tons weight, depending on speed, load and cycle of operation of mills. This wheel would have the same effect as the battery and eliminate the cost of maintenance, repairs, attendance, etc.

Figuring on this basis then, we have the cost as follows:

7½ mi. No. 000 bare copper wire 20,000 ft. at 25c.	$5,000
90 poles (150' apart) at $12 each	1,080
Erection at $3 per pole	270
Erection Trans. line (5 men, 1 week at $20 per) and details	150
Motor generator set complete with fly-wheel	10,000
Total	$16,500

The motor-generator set would cost, complete, probably about $10,000. The expenses not included will probably balance for either installation.

Now if we assume the power company to have available only the direct-current source of power as now used, we shall have to add to the above another motor-generator set of about 400 k.w. capacity at an additional cost of about $6,000. This will deliver the 2300 volts to the line. A 2100-volt motor on the first set, with 10 per cent. line loss, would make necessary No. 000 wire and 2300 volts at the power-house.

Again, if the power company has a three-phase or two-phase generator of sufficient capacity to deliver 400 k.w. to the line, 400 k.w. in step-up transformers can be used if the generators are wound for 220 or 440 volts. The cost of transformers will be about $2,500, which can be added to the above estimate in place of the motor-generator set last mentioned.

It may be that the power company has 6600 volts available for transmission, in which case the problem would be simplified even more. It seems probable, however, that they have no alternating-current generators or, if any, that they are of low voltage.

The idea of using alternating-current motors is not worth figuring on, as the direct-current equipment in the mill is undoubtedly better.

Aside from all consideration of economy as to first cost, the alternating-current transmission commends itself as much superior on account of cost of operation. As installed the system shows a loss of 37½ per cent. of delivered energy in transmission alone as against 10 per cent. using alternating current. Other than this, the efficiency of the mill will be about the same, using alternating-current or direct-current.

Figuring on 300 k.w. delivered for 12 hours each day, at a cost of 1½ cents per kilowatt-hour, we find a loss of 113 k.w. for twelve hours or 1350 kilowatt-hours, which at a cost of 1½ cents per kilowatt-hour means a loss of $20.40 per day, or in 300 days—a year—$6,100. Against this we have a loss of 10 per cent., or 30 k.w., which, at the same cost and time of use, figures out $1,620 a year loss. This means a saving in lost energy of at least $4,480. This is clearly a large item, representing as it does 12½ per cent of initial cost of direct-current installation, or 20 per cent. of alternating-current installation, using two motor-generator sets. This difference would be reduced, of course, approximately 10 per cent. by using the two motor-generator sets with the alternating-current installation, as the loss due to efficiency of first set would have to be considered.

Besides the above, a saving is made on maintenance, repairs, renewals, etc.

of the storage battery, which will be entirely eliminated by the substitution of a fly-wheel. This would probably make about 12½ per cent. of the initial cost. Placing this at $4,000 (the booster set to cost $6,000) it would mean a saving of $500 a year.

Test of a 500-K. W. Steam Turbine Alternator

SOME interesting tests of a steam turbine have been made by H. L. Rice, general manager, and W. M. Willett, electrical engineer, of the Western United Gas & Electric Company, in that company's plant in Aurora, Ill. A description of these tests and the results obtained are given below.

DESCRIPTION OF UNIT.

The steam turbine is an Allis-Chalmers-Parsons standard horizontal turbine, rated at 500 k.w. The generator is a standard Allis-Chalmers turbo-alternator, direct coupled to the steam turbines, and rated at 500 k.w. The condensing apparatus is of the Allis Chalmers standard turbo-jet type.

The characteristics of the unit are as follows:

Rated Capacity	500 K.W.
Speed	3600 R.P.M.
Frequency	60 cycles
Winding	2 Phase
E. M. F.	2200 Volts
Current per phase (Normal)	114 Amperes
Construction of alternator	2 Pole

The turbine was built to operate normally with steam pressure at 140 pounds gauge pressure at the turbine throttle, and a vacuum of 28 inches of mercury, referred to 30-inch barometer at the exhaust nozzle.

CONDITIONS OF TEST.

The time during which the turbine could be spared for test was limited from midnight Saturday to midnight Sunday; it was, therefore, decided to run only two tests, viz., one at 10 to 15 per cent. overload, and one at three-quarter load.

As the turbine was provided with a jet condenser, the steam consumption had to be determined by weighing the feed water, and to correct this, it was necessary to make a boiler leakage test during the time available for test purposes.

To determine the amount of feed water used, two barrels, "A" and "B," were placed on a platform and connected with one another by a short horizontal pipe introduced into the sides of the barrels near their tops. A water supply pipe with valves was brought over these barrels for the purpose of filling them alternately. Each barrel was provided with a large plug cock in the bottom. The barrels were carefully calibrated, and when filled so that the water would just enter the connecting pipe above mentioned, they were found to contain: "A," 413 pounds, and "B," 391¼ pounds of water at 58° F. As the feed water during the test was of a higher temperature, a correction has been made for the difference.

Under the platform, two receiving barrels were placed; into these the upper barrels emptied through the plug cocks mentioned. The lower barrels were connected with one another by a large horizontal pipe near their bottoms, and the suction pipe of the feed pump was brought into one of the barrels.

Two Stirling boilers, of 250 horsepower each, supplied steam to the turbine during the test. Each of the six drums of the two boilers was provided with a gauge glass, and readings of the water levels in all six drums were taken at the commencement and end of the test, and also during the test. The blow-off pipes were blanked off, as were also the feed connections to the other two boilers in the station.

The auxiliary steam header for the feed pumps, etc., was disconnected from the main header, and the portion of the main header receiving steam from the other two boilers in the station was separated from the portion receiving steam from the two boilers which furnished steam to the turbine during the test, by means of a gate valve which was closed tightly during the test. In order that there might be no leakage of steam through this valve, the pressure on all boilers was maintained at about the same point throughout the test, so that both sides of the valve were under approximately the same pressure. From the header supplying the turbine a pipe run to a 200 k.w. Hamilton-Corliss engine, which was shut down during the test, the angle valve on the header shutting off the pipe. Provision was made, near the engine throttle, to catch the drains from this pipe, but they were found insignificant and were disregarded.

The condensed steam from the steam header, as also from the steam separator near the turbine throttle, was discharged into barrels filled with a gauged quantity of cold water. As the water accumulated, it was taken out in buckets and weighed, and when the water in the barrel became sufficiently hot to vaporize, a weighed quantity of cold water was added. At the end of each test the water in the barrel was brought back to the original quantity.

The feed pump for supplying the calibrated feed water to the boilers was a duplex outside-packed plunger pump. The leakage from this pump was caught and returned to the lower feed water supply barrels. It was not necessary, therefore, to keep records of this leakage.

The steam gauges were checked by an inspector's test gauge which had been verified shortly before.

The quality of the steam during the test was determined by a throttling calorimeter, introduced into the steam pipe just below the separator at the turbine.

A water rheostat was used for providing load for the turbo-unit. Electrical readings were taken from the regular switchboard instruments in the station, and also from a set of calibrated instruments.

Between the overload and three-quarter load tests, the boilers were tested for leakage. To determine this, all valves were closed after the boilers had been filled to marks on the gauge glass, and the boilers kept under a steam pressure of 150 pounds per square inch for four hours. A calibrated quantity of water was then put into the boilers to bring the water level back to the original marks.

The following are the results of the test:

OVERLOAD TEST.

1. Average Load	570.8 k.w.
2. Per Cent. of Rated Load	114 per cent.
3. Duration of Test	4 hours
4. Steam Pressure at Turbine Throttle	143.3 gauge
5. Steam Pressure at Turbine Inlet	123.3 "
6. Vacuum Turbine Exhaust	26.77 inches
7. Barometer	29.5 "
8. Vacuum at Turbine referred to 30″ Barometer	27.22 "
9. Revolutions per minute	3600
10. Temperature of Feed Water	78.8
11. Total water used corrected for temperature	48544 lbs.
12. Drips from Steam Header	318.75
13. Drips from Steam Separator	68.25
14. Boiler Leakage	1927 lbs.
15. Moisture in Steam by Calorimeter	5.12 per cent.
16. Actual Weight of Water Chargeable to Turbine	43878.23
17. Actual Consumption of Dry Steam per k.w. per Hr.	19.21

THREE-QUARTER LOAD TEST.

1. Average Load	385.8 k.w.
2. Per Cent. of Rated Load	77.5 %
3. Duration of Test	4 hours
4. Steam Pressure at Turbine Throttle	142.4 gauge
5. Steam Pressure at Turbine Inlet	87.0 "
6. Vacuum Turbine Exhaust	27.57 inches
7. Barometer	29.45 "
8. Vacuum at Turbine referred to 30″ Barometer	28.08 "
9. Revolutions per minute	3600
10. Total water used corrected for temperature	34552.0 lbs.
11. Drips from Steam Header	397.0 lbs.
12. Drips from Steam Separator	91.5 lbs.
13. Temperature of Feed Water	86.16° F.
14. Boiler Leakage	1927 lbs.
15. Moisture in Steam by Calorimeter	4.48%
16. Actual Weight of water chargeable to Turbine	30612.01 lbs.
17. Actual Consumption of Dry Steam per k.w. per hour	19.83

Preliminary Program of the Washington Convention of the National Electric Light Association.

As we go to press the arrangements for the forthcoming convention of the National Electric Light Association are nearing completion. While a complete list of the papers to be read is not available that given is sufficient on which to predict many valuable contributions to technical literature.

The large number of points of interest in and about Washington also promises to add greatly to the enjoyment of the occasion. The program follows:

MONDAY EVENING.

Opening of the exhibition of the associate members—8 o'clock.

Reception, followed by dancing—9 o'clock. The reception will be held in the meeting room—music being furnished by a section of the Marine Band. Both the exhibition hall and meeting room are on the tenth floor of the new Willard Hotel.

TUESDAY, JUNE 4.

Opening Session 10 *O'Clock.*

Convention called to order by the president.

Address of welcome.

President's address.

Announcements, by the secretary.

Report of Committee on Progress, T. Commerford Martin, New York.

"Accidents," Paul Lüpke, Trenton, N. J.

"The Effect of Frosting Incandescent Lamps," Dr. Edward P. Hyde, Washington, D. C.

Need for an accurate maximum demand meter for measuring the true energy of polyphase service; a discussion led by Louis A. Ferguson, Chicago, Ill.

Executive Session.

Report of the Executive Committee, by the secretary.

Report of Committee on Membership Dues, W. H. Gardiner, New York, chairman.

Report of Committee to Revise Constitution and By-Laws, Samuel Scovil, Cleveland, chairman.

Afternoon Session, 2:30 *O'Clock.*

"Legal Justification for Differential Rates," George Whitefield Betts, Jr., New York.

"Recent Developments in Mercury Rectifiers," Frank Conrad, Pittsburg.

Report of Committee on Standard Rules for Electrical Construction and Operation," Ernest H. Davis, Williamsport, Pa., chairman.

Report of Committee on the Fire Hazard of Electricity, C. E. Skinner, Pittsburg, chairman.

Report on insurance and kindred matters, W. H. Blood, Jr., Boston, insurance expert of the association.

Report of Committee on Electric Light Accounting, H. M. Edwards, New York, chairman. Mr. Edwards will preside during the presentation and discussion of this report.

TUESDAY, JUNE 4.

Morning.

Automobile ride for the ladies. This will consist of a two-hour trip around Washington.

Afternoon.

President Roosevelt will give the members of the association a special reception.

Evening.

Theater party.

WEDNESDAY, JUNE 5.

Morning Session 10 *O'Clock.*

Report of Committee on the Present Methods of Protection from Lightning and other Static Disturbances, Alex Dow, Detroit, chairman.

"Recent Developments in Protective Apparatus," D. B. Rushmore, Schenectady, N. Y.

"New Developments in Arc Lamps and High Efficiency Electrodes," G. M. Little, Pittsburg.

Report of Committee on Electric Heating and Cooking, James I. Ayer, Boston, Mass., chairman.

"Electric Heating," C. D. Wood, New York.

"The Future of the Gas Engine," Lewis Nixon, New York.

"Producer Gas Engines for Central Station Work," (illustrated by stereopticon), Robert T. Lozier, New York.

"The Frequencies of Flicker at Which Variations in Illumination Vanish," Dr. A. E. Kennelly, S. E. Whiting, Harvard University.

"Efficiency of Various Methods of Illumination," (illustrated by stereopticon), E. A. Norman, New York.

Report of Committee to Consider Specifications for Street Lighting, Dudley Farrand, Newark, N. J., chairman. Dr. A. E. Kennelly will preside during the presentation and discussion of this report.

It is expected that several types of illumination will be on exhibition, including the Magnetite, Titanium, Flaming and Mercury Vapor Arcs; Moore Tube Lighting; Tantalum, Gem, Tungsten and Nernst Lamps.

Dr. C. P. Steinmetz, L. A. Ferguson, Peter Cooper Hewitt, F. W. Willcox, V. R. Lansingh, W. D. A. Ryan, and others have been invited to take part in the discussion.

Evening Session 8:30 *O' Clock.*

"Lightning and Lightning Protection," Dr. C. P. Steinmetz, Schenectady.

WEDNESDAY, JUNE 5.

Morning.

Automobile ride for the ladies.

Afternoon.

Exhibition cavalry drill at Fort Myer.

Evening.

Ladies of the convention are invited to attend the lecture of Dr. Steinmetz in the meeting hall at 8:30 o'clock.

At 9:30 o'clock there will be a ball in the small ballroom of the New Willard. Music by Haley.

THURSDAY, JUNE 6.

Morning Session, 10 *O'Clock.*

"Report of Freight Classification Committee, Ernest H. Davis, Williamsport, chairman.

"Report of Committee on Relations between Manufacturers and Central Stations, Henry L. Doherty, New York, chairman.

"Indefinite Candle-Power Ratings in Municipal Contracts and the Experience of The Colorado Springs Electric Company."

"Recent Turbine Developments," W. L. R. Emmet, Schenectady.

"The Electric Automobile as an Adjunct to Central-Station Load," H. H. Rice, Indianapolis, Ind.

"Some Power Experiences," S. M. Sheridan, Detroit, Mich.

"Municipal Ownership," Arthur H. Grant, New York.

"Why We Failed in a Municipal Ownership Campaign," Glenn Marston, New York.

"Italian Methods of Charging for Electric Current," Signor Ing Guido Semenza, Milan, Italy.

Report of Membership Committee, J. Robert Crouse, Cleveland, chairman.

Report of Committee on Relations with Local Associations, S. R. Bradley, Jr., Nyack, N. Y., chairman.

Report of Committee on the Grounding of A. C. Secondary Circuits, W. H. Blood, Jr., Boston, chairman.

Evening Session, 8:30 *O'Clock.*

Executive Session.

Report of Committee on Rates and Costs, R. S. Hale, Boston, Mass., chairman.

Report of Public Policy Committee, Everett W. Burdett, Boston, Mass., chairman.

Mr. Everett W. Burdett, chairman, will preside, and it is expected that Messrs. Charles L. Edgar, Samuel Insull, Alex. Dow, Henry L. Doherty, Joseph B. McCall, J. W. Lieb, Jr., and

Samuel Scovil will participate in the discussion.

THURSDAY, JUNE 6TH.

Morning.

Automobile ride for the ladies.

Afternoon.

A visit to Mount Vernon, going by boat. The excursion will go as far down the Potomac River as Indian Head, returning in time to reach the Washington Wharf at about 6 P. M.

Evening.

Visit of the ladies to the Congressional Library.

FRIDAY, JUNE 7TH.

Commercial or New Business Day.

Morning and afternoon sessions at 10 o'clock A. M. and 2 o'clock P. M. Adjournment for luncheon at 1 o'clock.

"Scope and Character of Papers and Discussion," W. W. Freeman, Brooklyn, N. Y.

The Commercial Field.

Report of National Electric Light Association Co-operating Committee, W. W. Freeman, Chairman, Brooklyn, N. Y. (To be read by some member of the committee designated by the chairman.)

"Co-operative Commercialism in the Electric Field," J. Robert Crouse, Cleveland, Ohio.

"Possibilities of Commercial Development," Henry L. Doherty, New York.

"New Business—How to Get It—How to Keep It," F. M. Tait, Dayton, Ohio.

"New Business Results Demonstrated in Cities of All Sizes," J. E. Montague, Niagara Falls *Reporter.*

Discussion.

Questions of Policy.

"Sales Policy in Combination Gas and Electric Companies," F. A. Willard, Rochester, N. Y.

"The Electrical Jobbers and Dealers Co-operation in Business Getting," R. V. Scudder, St. Louis, Mo.

"Co-operation of the Electrical Trade Papers in Business Getting," F. W. Loomis, Savannah, Ga., *Reporter.*

Discussion.

Wiring.

"How to Get the Old Buildings Wired," F. H. Golding, Dayton, Ohio.

"How to Get the New Buildings Wired," J. Sheldon Cartwright, Knoxville, Tenn.

"Co-operation of the Electric Contractor in the Wiring of Buildings," James R. Strong, New York, President The National Electrical Contractors' Association of the United States.

Discussion.

The Solicitor.

"Sizing up the Territory—Preparing the Lists of Prospective Customers," George Williams, Cincinnati, O.

"Qualifications of Solicitors for Different Classes of Business," F. W. Frueauff, Denver, Col.

"How to Measure Results and Pay Solicitors," Leon H. Scherck, Birmingham, Ala.

"Increasing the Efficiency of the Sales Force," J. D. Kenyon, Chicago, Ill.

"Value and Use of Solicitors' Handbook," R. S. Hale, Boston, Mass.

Discussion.

Adjournment for luncheon.

Advertising.

"A Balanced Advertising Program," Ralph Richardson, Jackson, Tenn.

"Advertising Results Demonstrated in Cities of All Sizes," E. S. Marlow, Washington Reporter.

"How to Make the Most of Newspaper Advertising," A. D. Mackie, Peoria, Ill.

"Measuring the Results of Advertising," M. S. Seelman, Jr., Brooklyn, N. Y.

"Value of the Service of the Advertising Agency or Specialist," Lawrence Manning, Owosso, Mich.

"Display Room and Demonstration as Business Getters," E. R. Davenport, Providence, R. I.

"New Business by Indirect Methods," L. D. Mathes, Dubuque, Iowa.

Discussion.

Light.

"Illuminating Engineering as an Aid to Securing and Retaining Business," C. F. Oehlmann, Cincinnati, Ohio.

"Methods of Securing Residential Business," R. W. Hemphill, Ann Arbor, Mich.

"Co-operative Lighting of Streets by Merchants," H. J. Gille, St. Paul, Minn.

"Methods of Securing Sign, Window and Outline Lighting," Homer Honeywell, Lincoln, Neb.

Discussion.

Power.

"Methods of Securing Power Business," George N. Tidd, Scranton, Pa.

"Catering to Power for Automobile Charging," R. W. Rollins, Hartford, Conn.

"Establishing Day Circuits in Towns of 10,000 Population and Under," F. H. Plaice, New Bremen, O.

Discussion.

Heating.

"Methods of Exploiting Electric Heating Devices, T. K. Jackson, Mobile, Ala.

Discussion.

"Review of Advertising" (illustrated with stereopticon slides), C. W. Lee, Newark, N. J.

"Memorial," T. C. Martin, New York.

Report of the Nominating Committee.

Election of officers for the ensuing year.

Adjournment.

E. S. Marlow, 213 Fourteenth Street, Washington, is chairman of the hotel committee, and E. E. Bondy, 55 Duane Street, New York, is vice-chairman.

Second-Hand Edison Lamp Ruling.

A PERMANENT injunction has been issued by the United States Circuit Court, District of New Jersey, restraining William F. McKeon and Joseph Conning, of Newark, N. J., from selling second-hand incandescent lamps unless marked, "Used and Second-Hand." The decision, signed by Judge Crose, ends a litigation between the General Electric Company and the defendants, extending over a period of three years. Similar suits were instituted, one against Edward Mills, proprietor of the Newark Electrical Supply Company, and the other against Frederick W. Chase, proprietor of the Lamp Supply Company, of New York. Neither of these parties defended the suit, and decrees were therefore taken against them by default.

Consul-General Ridgely, of Barcelona, Spain, reports an increased importation of electrical fixtures into that country. In 1895, electric light appliances to the value of $200,000 were imported, of which the United States supplied $5,429. The import situation is in the hands of French and German firms. The total number of incandescent lamps used in Spain for street lighting is 119,105, and 1691 arc lamps. About one million and a half incandescent lamps; 8000 arc lamps and 3000 motors are now in use for private use. The whole electrical equipment of the entire country is much less than that of several of the cities in the United States.

The Business World, issued by the Denver Gas & Electric Company, for April, shows sixty-four contracts for power aggregating 426 horse-power, and thirty-one new signed contracts.

Electrical Equipment of a Pulp and Paper Mill.

THE power requirements of pulp and paper mills present many problems arising from conditions peculiar to this class of industries. Continuity of service and uniform speed are essential to the successful manufacture of paper, because when a run is started it must be continuous, and any lack of uniformity in speed seriously affects the quality of the product. The starting conditions of some of the machinery are severe and a large overload capacity in the motive power is therefore necessary.

Electric motors have been found to fulfil all these requirements and have been adopted to a large extent by pulp and paper manufacturers. An important feature is that portion of paper machines operating at variable speeds and including the wire, press rolls, dryers and machine rollers. It is essential that the speed variations cover a considerable range, be easily controlled and complexity avoided as far as possible.

An interesting example of this class of work is found in the plant of the Grand Rapids Pulp & Paper Company at Grand Rapids, Wis. The mills are located on the Wisconsin River, about four miles from the town, where an abundance of water-power is available. This company strongly advocates the use of electric drive and fully realizes the many advantages derived from its use. The electrical equipment was laid out by V. D. Simons, general manager of the company, and installed under his direct supervision. The plant possesses mechanical and electrical features of interest and the entire installation is an example of modern engineering practice.

The pulp mill, where the stock is prepared for the manufacture of paper, is operated by water-power, but the various processes afterward carried on employ electric drive.

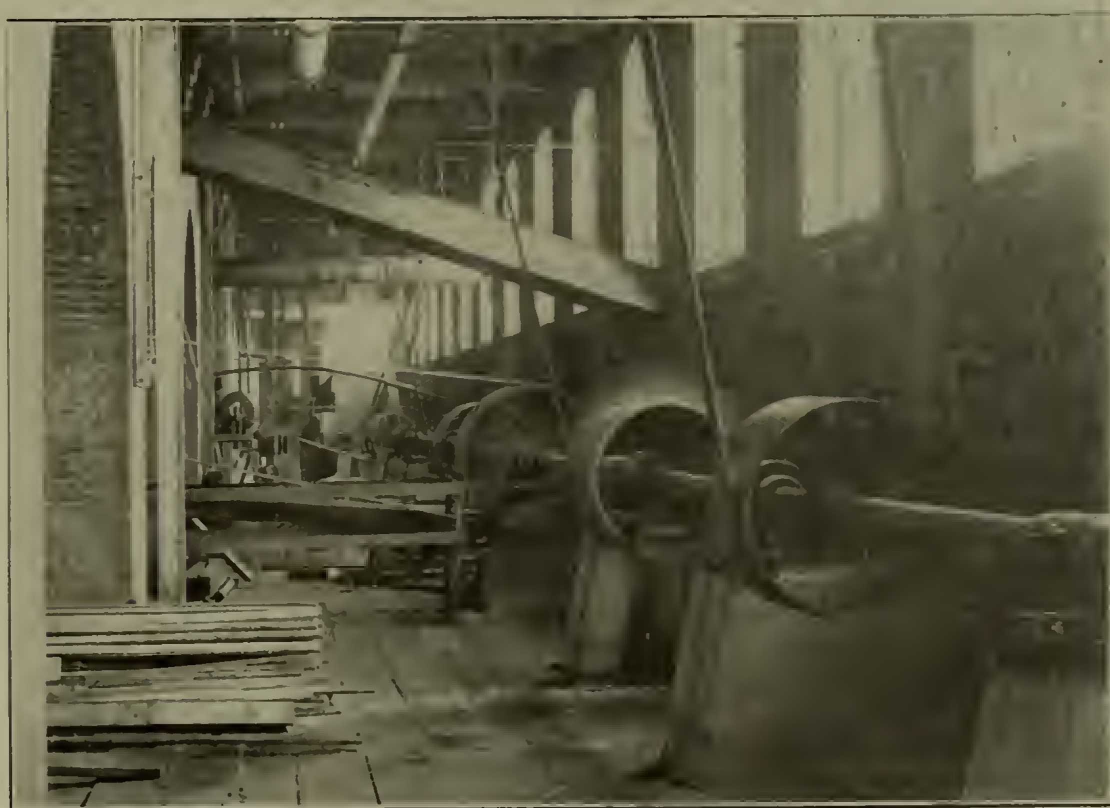
One of the essential conditions of paper-making is that as the weight or thickness changes, the speed must be easily altered to provide for changes in the rate of production, which is usually accomplished by mechanical means. In the present case, however, the engineer accomplishes this result by the use of variable-speed motors.

There are two Beloit paper machines, the smaller of the two having a capacity of 525 feet per minute or a total of 21 tons per day, the width of the paper being 84 inches before and 78 inches after trimming. There are 29 dryers and a 70-foot wire. That portion of the machine which operates at variable speeds is driven by a 100 horse-power Westinghouse variable-speed, shunt-wound motor, with a speed variation of 470 to 750 revolutions per minute, obtained by field control. The actual power required, as shown by tests, to drive the variable-speed portion of the machine under normal working conditions, *i. e.,* 525 feet per minute, is 101 horse-power. That portion of the machine which operates at constant speed is driven by a 50 horse-power Westinghouse motor.

A 100 HORSE-POWER VARIABLE-SPEED MOTOR OPERATING VARIABLE-SPEED PART OF A PAPER MACHINE.

The larger machine has a capacity of 26 tons of paper per day, at the rate of 475 feet per minute, 104 inches wide before trimming and 97 inches after trimming, and is provided with 25 dryers and a 60-foot wire. The variable-speed portion is driven by a 100 horse-power Westinghouse direct-current, shunt-wound motor, with a speed variation ranging from 470 to 750 revolutions per minute, obtained by field control. Actual power determined by tests to drive the variable speed is 97 horse-power. The constant-speed portion is driven by a 50 horse-power Westinghouse motor. The use of shunt-wound motors permits the use of field control, which has the advantage of high efficiency and good regulation throughout its range.

In the cutter room are two cutters and an elevator operated by a 10 horse-power Westinghouse back-geared motor. An interesting feature



ARRANGEMENT OF SHAFTING FOR VARIABLE-SPEED DRIVE OF PAPER MACHINE.

A BELOIT PAPER MACHINE TURNING OUT 500 FEET OF 104-INCH PAPER PER MINUTE.

in connection with this motor is that it replaced 250 feet of $3\,{}^{7}/_{16}$-inch line shaft.

A 10 horse-power Westinghouse, driving a full equipped machine shop for general repair work, completes the electrical equipment.

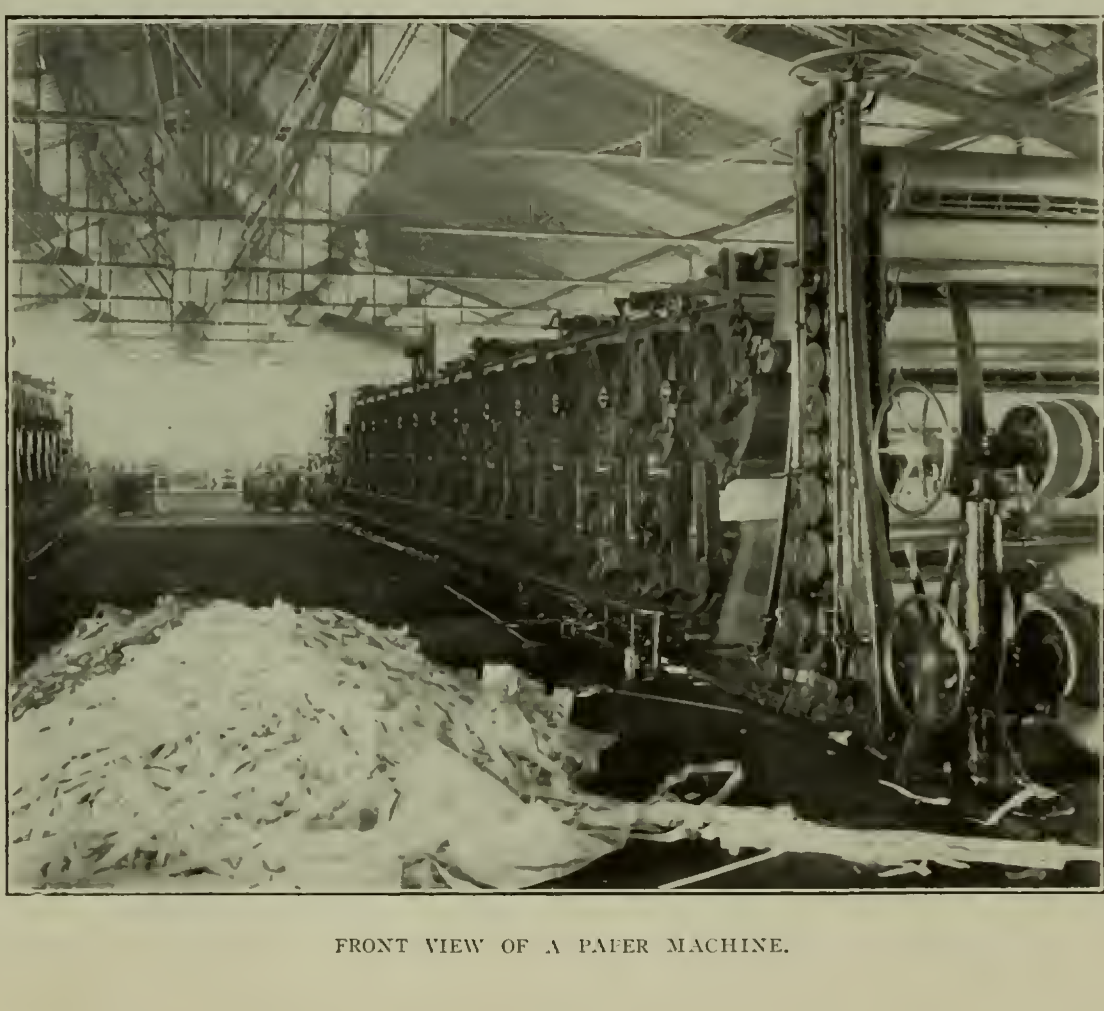
The present daily average output of this company is 45 tons of newspaper.

The boiler plant consists of four return-tube units 72x16 inches, equipped with American under-feed stokers. The furnaces are the Dutch-oven type, arranged for burning refuse wood and screening coal. A 54-inch Buffalo Forge Company's fan, operated by a Westinghouse 10 horse-power variable-speed motor, furnishes forced draft.

The generator equipment consists of one Westinghouse 200 k.w., 220-volt, engine type, direct-current generator, direct connected to a 22x36-inch Corliss engine operating at 125 revolutions per minute, and one Westinghouse 150 k.w. generator of the same characteristic belted through a countershaft to a water-wheel. The rated speed of the generator is 600 revolutions per minute, and it operates in parallel with the engine-driven machine.

An interesting feature in the regulation of the water-wheel is the arrangement for controlling the gates. They are operated by a Westinghouse series-wound reversible back-geared motor, started, stopped and reversed by means of a double push-button on the switchboard. There is also an attachment on the governor of the engine for automatically controlling the motor, thus regulating the respective loads of the two generators.

The switchboard is of standard Westinghouse construction and consists of two generators and three feeder panels.



FRONT VIEW OF A PAPER MACHINE.

Electricity and Refuse Destructors

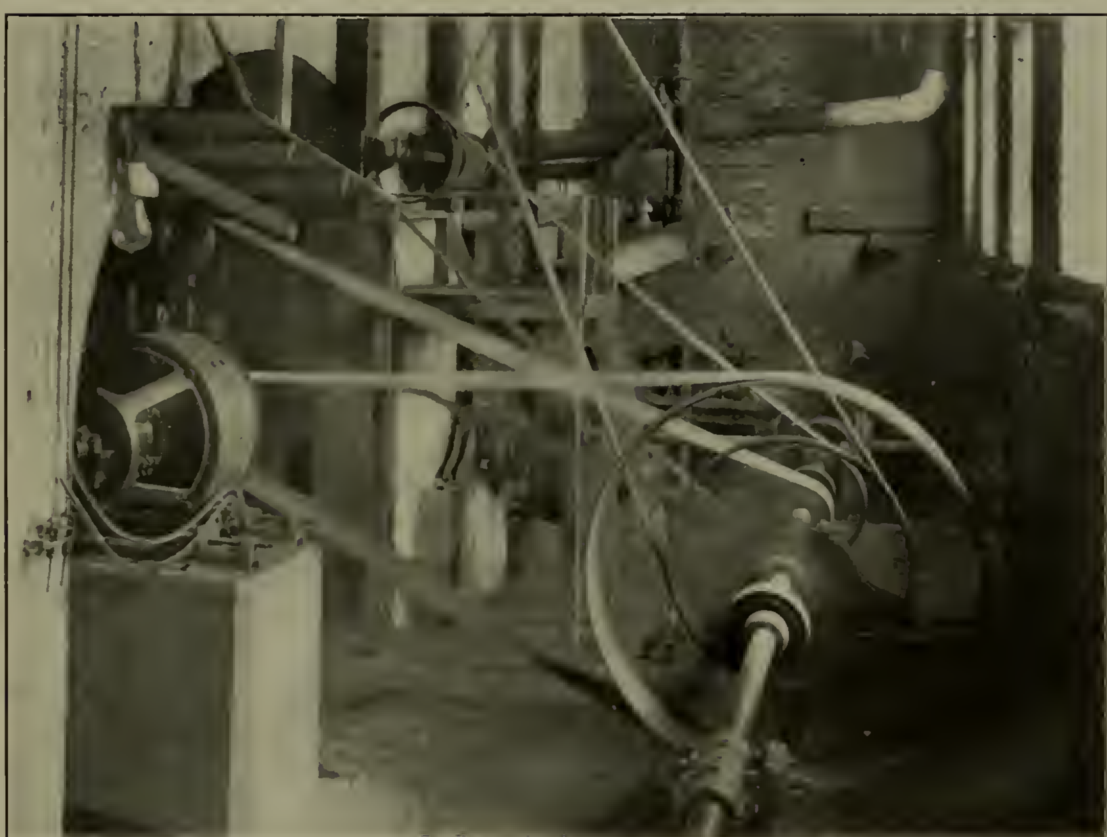
SOME particulars of the results obtained by the use of refuse destructors in generating steam for electric plants are given by A. J. Abraham in a recent issue of *The Electrical Review*, of London. The average results obtained in a number of towns of about 20,000 inhabitants show that the amount of refuse destroyed annually was 4680 tons, and the number of kilowatt-hours generated was 200,000.

In Cambuslang, where the destructor and the electric-lighting station are run together, 72 tons of refuse are destroyed each week, and 2520 kilowatt-hours are generated, making 35 kilowatt-hours generated for each ton of refuse. Only 716 kilowatt-hours are generated by the use of coal, and this is in spite of the fact that no battery is installed at the station for balancing the load. With a battery, the author believes, it would be easy to obtain 50 kilowatt-hours per ton of refuse, and he thinks it safe to allow an average of 40 for all properly constructed stations working with refuse destructors.

The boiler pressure advisable is 2000 pounds per square inch, which would be reduced to 150 pounds at the engine. Out of the 200,000 kilowatt-hours to be generated in a small town burning 4680 tons of refuse, 187,200 kilowatt-hours may be generated from the refuse, making a saving of about $2,000 in coal. Combined power-stations and destructor works for larger towns of from 40,000 to 50,000 inhabitants have in all cases been a failure, and the more the load on the station increases, the greater is the necessity for moving the destructor away.

At Hackney, with a population of over 200,000, the cost to generate 1,500,000 kilowatt-hours from refuse was about $11,000, while the cost of generating 1,470,000 kilowatt-hours from coal was only $5,900. At Preston a destructor is working very satisfactorily in conjunction with a street railway power-station. Were this de-

BACK VIEW OF PAPER MACHINE SHOWING METHOD OF DRIVING FROM BENEATH THE FLOOR.



A 50-HORSE-POWER MOTOR DRIVING CONSTANT-SPEED PART OF 86-INCH PAPER MACHINE.

tructor combined with the electric light plant the results would not be so satisfactory.

The relative advantages and disadvantages of the top-feed and the front-feed types of destructor are given as follows:

The top-feed type is more expensive to work than the other, because, when steaming, men are required both on top and at the fires in front.

With the front-feed destructor the same men can stoke and clinker out, reducing the labor cost to almost half. The refuse tipped on the hot cell tops is a nuisance and is unhealthful. The work of pushing the fuming material into the top door is very disagreeable. Moreover, these doors are troublesome to keep in order. On general principles, the fewer openings there are in a cell, the better, as it is not advisable to have any openings in the furnace crown. With a front-feed destructor there is no objectionable odor, the destructor is more easily worked, and in many cases it is actually a disadvantage to dry the refuse before burning it, as much of the calorific value is lost.

Trade News.

The city of Marshfield, Wisconsin, has practically finished the building for housing its new electric light and water works plant, and has now begun the installation of equipment. Concrete foundations have been prepared for supporting two Allis-Chalmers Reliance belted engines which will be used to drive two Allis-Chalmers alternating-current generators, one of 225 k.w capacity, and the other of 100 k.w. The engines are 14x30 inches and 18x42 inches respectively, and the generators are 60-cycle, 3-phase machines. Of these two units the smaller will be used to carry the day load, leaving the larger portion of the lighting load for the larger machine. Three new 150 H. P. boilers of the horizontal tubular type, 72 inches x 18 feet, will generate steam for the operation of the station.

Owing to the very rapid increase of eastern business in power and fan motors, The Robbins & Myers Company, Springfield, O., have recently moved their New York office and salesroom from 66 Cortlandt street to 145 Chambers street, where they occupy a five-story building. The New York office will henceforth look after all New England trade and make deliveries from New York.

The Moore Electrical Company, of Newark, N. J., has lately sent, via the Hamburg-American liner Deutschland, two men and apparatus for two installations of the Moore light in the largest automobile garage in London. This is the first foreign installation of the Moore light.

Voltax liquid compound now coming into extensive use as a weatherproof paint, has just been specified by the Board of Education of New York City as a standard paint for painting and enameling on screens, radiators, coils and connections. Voltax will be used as a paint on pneumatic pipes, valves, canvas coverings on smoke pipes, grease extractors, economizer connections, feed water heaters, receiving tanks, boiler and incinerator fronts and on all fixtures, boilers, engines, pumps, blowers, foundations, steel bands and tanks set in the floors.

The Vulcan Iron Works Company, Toledo, O., have changed the power in their plant from direct-current 500 volts to alternating-current, 440 volts. A transformer station has been installed, and the machinery will now be driven by Westinghouse, Type F. variable speed motors, connected direct to each machine.

10 HORSE-POWER BACK-GEARED MOTOR OPERATING MACHINES IN THE CUTTER ROOM AND ALSO THE ELEVATOR (see page 249).

The Abner Doble Company, Engineers of San Francisco, have appointed Mitsui & Company to act as their sole agents in Japan and its territories, Korea, China and Manchuria, for the sale of Doble tangential water wheels and hydraulic apparatus. The industrial development now taking place in the Orient, and the increasing demand for high grade water wheel machinery will make this co-operative arrangement an advantageous one for both parties. Mitsui & Company is the largest and most progressive engineering house in the Far East and, with its thirty-five branch offices, is in a particularly good position to handle the water wheel products of the Abner Doble Company.

The New York office of the B. F. Sturtevant Company has just been removed from 131 Liberty Street to the Engineering Building, at 114 Liberty Street, where much better facilities will be provided for conducting the rapidly increasing business of this company.

The new power-house of the Edison Electric Company of Los Angeles, California, on the Kern River, is nearing completion. The initial electric generating equipment provides for an output of some 20,000 kilowatts. The power will be transmitted by pole lines to Los Angeles and to Santa Barbara. Four General Electric Company 5000-kilowatt, 3-phase, 50-cycle, generators have been installed. These large machines are water-wheel driven at 250 revolutions per minute, delivering current at a potentiol of 2300 volts to the secondaries of the transformers. Each of the thirteen transformers has a capacity of 1667 kilowatts, the primaries being arranged with taps to provide for Y connections at several different potentials, the highest being 75,000 volts and the lowest 33,000 volts. The secondary windings are arranged for delta connection at 2300 volts.

Such excellent progress has been made during the fall and winter months on the construction work of the Milwaukee Northern Railway, which will open up communication between the Eastern Wisconsin towns of Sheboygan, Port Washington, Fond du Lac, West Bend and numerous others in this populous district and Milwaukee, that it will probably be ready for operation on at least one division by early summer. The complete power equipment was purchased from the Allis-Chalmers Company, of Milwaukee, and is of standard Allis-Chalmers design, both for gas engines and alternators. The electrical features of the equipment may be briefly described as follows: Three-phase alternating current will be generated in the power-house at 405 volts by three direct-connected alternators each of 1000 k.w. normal capacity, driven at 107 revolutions per minute by Allis-Chalmers twin-tandem gas engines, each with a rated capacity of 1500 H. P. This equipment when in operation will enjoy the distinction of being the largest installation in America of gas-engine-driven electric generating units for traction purposes. The main power-house is located at Port Washington, and sites for substations have been provided at the following points: Burleigh, Cedarburg, Georgia avenue, Marblehead, Brown Deer, Cedar Grove, West Bend and Campbellsport.

A. D. Granger announce the removal of their New York office from 95 Liberty street to 90 West street. The Granger Company is agent for the Skinner Engine Company of Erie, Oswego Boiler & Engine Company, and the Bates Machine Company, of Joliet, Ill.

A prospectus has been issued of the Colorado-Wyoming Electric Company, incorporated under the laws of the State of Nevada, with a capital stock of $350,000 and formed for the purpose of acquiring and operating the electric power and light properties of Ouray, Colorado, and Laramie, Wyoming. This change practically means that the Ouray Electric Power & Light Company has absorbed the Laramie property.

The Interborough Company, of New York, has just placed a large order with the Electric Cable Company, of No. 17 Battery Place, New York City, for flexible mesh rail bonds, which, it is said, will hereafter be used exclusively by this company. To meet the rapidly growing demand for this product the Electric Cable Company is building an extensive addition to its plant at Bridgeport, Conn.

Among recent improvements in the car stations of the International Railway at Buffalo are four three-motor electric traveling cranes of ten tons capacity, operating one overhead electric track and trolley, furnished by the Northern Engineering Works, Detroit, Mich.

One of the most distinctive of the numerous fireproof structures now in process of erection in San Francisco is the power station now being built by Frank B. Gilbreth for the City Electric Company, a corporation formed by local men. The building will be along lines very similar to that recently completed by the same contractor for the Seattle Electric Company at Georgetown, Wash., the relation of the engine and boiler room being exactly the same. The structure will be of reinforced concrete and is planned to furnish space for two Parsons steam turbines of 2000 k.w. capacity, with four batteries of water-tube boilers which will furnish light, heat and power for various commercial purposes. The engine room will be 45 by 70 feet and the boiler room adjoining 84 by 70 feet, with a height of 35 feet. In the engine room will be a traveling crane of 40 tons capacity. Requirements for the structure are that it shall be thoroughly fireproof, and, in so far as is practicable, earthquakeproof. Work on the foundations is new well under way. At an estimated cost of $105,000 the building has been planned by, and is being erected under the supervision of S. L. Napthaly, engineer for the company.

The San Francisco office of the General Electric Company is now permanently located in the Union Trust Building, in San Francisco. Since the fire the office has been located in the Union Savings Bank Building at Oakland, large temporary warehouses having also been erected in the same city.

The Northern Engineering Works, Detroit, Mich., has furnished the plant of the Edison Sault Electric Company, Sault St. Marie, Mich., with a second 15-ton alternating-current crane.

The Bureau of Supplies and Accounts, Navy Department, will open bids on May 21st and 28th, and June 11th for electrical material as specified below. Bidders will receive schedules for the material on which they desire to bid by giving the schedule numbers desired by direct application to the Bureau of Supplies and Accounts, or to the navy pay office nearest each navy yard.

ELECTRICAL MATERIAL.

Article.	Quantity.	Delivery at Navy Yard.	Sched.
Armatures for motors	3	Wash., D. C.	775
Battery for electric launch (92 cells)	1	Norfolk, Va	782
Cabinets, rammer, c. b	4	do	775
Controllers, rammer.	4	do	775
Current, electric	27,600 k. w. hrs	Key West, Fla	759
do	1,058,400 k. w. hrs	Mare Island, Cal	704
Fixtures, electrical	Miscellaneous	Pensacola, Fla	759
Irons, electric soldering	36	League Island, Pa	788
Machine, magnet winding	1	Mare Island, Cal	706
Motors	2	do	706
Motor-drive outfit	1	do	706
Motor, induction	1	Boston, Mass	782
Tape, cotton, insulation	1,300	New York	796
Wire	8,000 feet	Pensacola, Fla	759

The Heine Safety Boiler Company, of St. Louis, Mo., reports some recent sales as follows:

Asano Cement Company, Tokio, Japan, four boilers, aggregating 900 horse-power.

Atlantic, Gulf & Pacific Company, stalled on two hydraulic dredges, makfour 200 horse-power boilers, to be ining the fifth order.

American La France Fire Engine Company, Elmira, N. Y., two 230 horse-power.

American Locomotive Works, Richmond, Va., four 400 horse-power boilers.

Bridgeport Forge Company, Bridgeport, Conn., three 250 horse-power boilers.

Crown Cotton Mills, Dalton, Ga., two 400 horse-power boilers.

Home Brewery, Columbus, O., three 200 horse-power boilers.

Hudson Companies, two 316 horsepower boilers, making a total to this company of 4513 horse-power on eleven orders.

Independence Kansas Cement Company, Independence, Kas., three 400 horse-power, making the second order.

James S. Kirk Company, Chicago, two 500 horse-power boilers.

Joseph J. Little Building, New York, three 275 horse-power boilers.

Quincy Horse Railway & Carrying Company, Quincy, Ill., three 316 horse-power.

City of New York for Ridgewood Pumping Station, eight 300 horsepower.

Pueblo & Suburban Traction & Lighting Co., Pueblo, Col., one 378 horse-power.

Denver Gas & Electric Company, Denver, Col., three 524 horse-power boilers.

Texas Company, Beaumont, Tex., thirty-two 200 horse-power boilers for eight pipe-line oil pumping stations in Texas.

Victor Talking Machine Company, Camden, N. J., two 316 and two 270 horse-power.

Warren Manufacturing Company, Warren, R. I., one 323 horse-power boiler, making a total of 2881 horsepower on six orders.

Williamette Pulp & Paper Co., Oregon City, Ore., one 250 and two 366 horse-power; third order.

U. S. Navy Department for Norfolk Navy Yard, two 428 horse-power boilers and four 350 horse-power boilers.

U. S. Navy Department for Charleston Navy Yard, through Muralt & Company, New York, four 350 horsepower boilers.

Philadelphia House of Refuge, Glen Mills, Pa., four 250 horse-power.

The B. F. Sturtevant Company, of Boston, Mass., report sales of electric propeller fans as follows: The Jeffrey Manufacturing Company, Columbus, O.; Victor Talking Machine Company, Camden, N. J.; Samuel Jackson Company, Pawtucket, R. I.; Heyl & Patterson, Pittsburg, Pa.; E. Greenfield's Son & Company, Brooklyn, N. Y.; Ingersoll-Rand Company, Phillipsburg, N. J.; Wosterburg & Williams, New York City; Goodman Manufacturing Company, Chicago, Ill.; Wheeler-Green Electric Company, Rochester, N. Y.; Corbin Motor Vehicle Corporation, New Britain, Conn.; Thos. G. Plant Company, Jamaica Plain, Mass.; Ideal Lunch, Boston, Mass.; Jackson & Company, Boston, Mass.; Harris-Emery Company, Des Moines, Ia.; and Fred Odenbach & Son, Rochester, N. Y.

Owing to the large increase in the business of the Electric Cable Company, an extensive addition is to be made to its plant at Bridgeport, Conn. The new building will be constructed of concrete and brick and will embody the most improved forms of fireproof construction and equipment. The addition will be devoted exclusively to the production of weatherproof wires and cables.

Dossert & Company, of New York, have received an order from the Bureau of Yards and Docks, United States Navy Yard, Portsmouth, N. H., for 140 Dossert solderless 2-way joints, cable taps and standard terminal lugs for connecting underground cables of 1,000,000 C. M. and 500,000 C. M.

The General Electric Company announces an issue of $13,000,000 10-year 5 per cent. debenture bonds, convertible after June 1, 1911, into the stock of the company at par and redeemable after that date at 105, subject, however, to the stockholders' right of conversion. The new bonds will be offered to stockholders for subscription at par to the extent of 20 per cent. of their holdings. Rights will accrue to stockholders of record on June 20 and subscriptions will be closed on July 20. Payments will be due 50 per cent. on July 20, 1907, and 50 per cent. on January 20, 1908. The stockholders have the privilege of making full payment on the first date mentioned, whereupon bonds, or negotiable receipts therefor, will be delivered to the subscribers. The proceeds from the sale of these bonds will be used for additional working capital. President Coffin, in the annual report of the company, recently issued, foreshadowed the sale of new securities by a statement that the increased business of the company would soon make it necessary to raise fresh funds.

New Catalogues

The Trill Indicator Company, of Corry, Pa., is distributing a book on indicators, reducing wheels and planimeters. Besides a full description of the company's products the book also contains much useful and handy information about taking and reading indicator cards. It shows in detail how to tap the cylinder, make pipe connections, place the indicator, connect it with the cross-head, adjust the tension, etc. The indicator diagram for a single cylinder engine is carefully analyzed and rules given for finding the horse-power. Characteristic diagrams from engines of various types, including faulty diagrams, are analyzed and suggestions made for their correction. The book will be of interest to every steam engineer.

A neat pamphlet sent out by the United Electric Light & Power Company, of New York, is entitled, "Power Pointers. As the name indicates, a number of reasons are advanced why electricity should be used for industrial operations. The subject is treated rather generally and very briefly, the object being to open the way for a solicitor. The illustrations are well executed and the typographical work is of a high order.

The Pittsburgh Transformer Company is now sending out a complete catalogue issued on its product. The most meritorious feature of the catalogue is the frankness with which the company discusses the building and testing of its product.

A recent pamphlet sent out by the H. T. Paiste Company, of Philadelphia, contains price lists of their electric light supplies.

A very complete catalogue issued by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y., is devoted to coal-handling machinery. Among the equipment illustrated and described are steeple towers, freight-handling cranes, coal-storage plants, cable railways, steam and electric hoisting engines, conveyors, scales, weighing hoppers, coal crackers, grab buckets, blocks, sheaves, barrows, industrial railway equipment and electric locomotives.

The H. T. Paiste Company, of Philadelphia have just issued May Bulletin No. 43, in which is shown three new panel cut-outs, also wiring diagrams of each style of cut-out.

The Robbins & Myers Company are sending out a unique folder, Bulletin No. 55, picturing the standard fans manufactured by that company.

"Electric Jingles," a book of alphabetical rhymes written by Carmelita Beckwith and illustrated by F. G. Cooper, has been compiled for use by central stations in calling the attention of prospective customers to the many and varied uses of current for domestic and commercial purposes. Both rhymes and pictures are very entertaining and should predispose the readers favorably toward the efforts of the company to induce them to adopt electrical service.

Copper and Brass is the title of a new publication sent out by the Copper and Brass Publishing Co., of Detroit, Mich., and devoted to the non-ferrous metal trades. The initial number appeared March, 1907. The publication is 9x12 inches and contains 34 pages almost exclusively devoted to commercial quotations and to the business problems of the industry.

"The House Without a Kitchen Chimney" is the title of an attractive pamphlet sent out by the Philadelphia Electric Company to its customers. It is the house of Mr. Hillman, of Schenectady, which is featured. Mr. Hillman's experiment shows that at 5 cents per kilowatt-hour, the cost of lighting and heating his home was about on a par with the cost of coal and gas. The booklet gives cost and current data for a score of heating specialties.

Recent literature sent out by the General Electric Co., of Schenectady, N. Y., includes bulletins devoted to belt-driven alternators ranging from 30 to 200 k.w., "Security" snap socket etc, "GEM" high-efficiency incandescent units, and constant-current transformer panels for series arc and series incandescent lighting systems. Price lists are also given for Thomson recording wattmeters and "GEM" regular incandescent units and "GEM" meridian units. One folder deals with adjustable terminal ground connectors, and another gives an approximate rule for size of wires for three-phase transmission lines. A useful blotter is devoted to calling attention to the need of lightning arresters.

A recent bulletin issued by the B. F. Sturtevant Company, of Boston, Mass., illustrates and describes electric propellor fans. These are built in a full line of sizes from 18 to 120 inches, and are carried in stock at works and branch warerooms in sizes up to 48 inches, wound for 110 and 220 volts. Both fan and motor are manufactured by the B. F. Sturtevant Company. The motor is dustproof; the fan may be placed in any location and controlled by switch from a distance.

Personal

Professor H. E. Clifford, of the electrical engineering department of the Massachusetts Institute of Technology, will next year extend his notable lectures on alternating currents into a graduate course. These lectures have hitherto been restricted to the required work in alternating currents of the undergraduate students, but during the next college year Professor Clifford will deliver an advanced course which will be particularly intended for graduate students who are attending the Institute for the purpose of spending a fifth year in the Engineering School, or for the purpose of their obtaining a second degree. These lectures are expected to be among the most brilliant and complete that have yet been presented on the subject in any of the engineering schools of America.

George W. Martin, for two years associate editor, and for the past year editor of *The Electrical Age*, on March 15th resigned his position to resume engineering work. Mr. Martin is now in the engineering department of the New York Edison Company.

George P. Hutchins, the well known advertising agent, has removed his offices from 120 Liberty street to 500 Fifth avenue, New York City.

J. H. Hallberg, consulting engineer, is now devoting part of his time to the design and manufacture of flaming arc lamps and other electrical specialties. His office is now at No. 30 Greenwich avenue, New York City, with the Beck Flaming Lamp Company, for whom is acting as engineer and general manager. Mr. Hallberg will, however, retain his old clients and do a general consulting engineering business.

Frank S. Washburn and Charles H. Baker, of New York, have acquired the American rights for the manufacture of calcium cyanamid, an electro-chemical compound developed by Professor Frank and Dr. Care of Germany. Calcium cyanamid is popularly known as "lime nitrogen," and is chiefly used as an agricultural fertilizer, though it is expected it will be extensively used in the chemical arts for the production of ammonia and nitric acids. It is understood that Messrs. Washburn and Baker will extensively employ the power of certain large water powers which they have under development along the Tennessee River for the manufacture of the new fertilizer.

Membership Campaign of The National Electric Light Association

An interesting pamphlet is that recently sent out by the National Electric Light Association, through the chairman of its membership committee, J. Robert Crouse. It contains some thirty letters from electricity supply companies, telling of the advantage to them of membership in the association. Without an exception all concur in the opinion that the value received is many times more than the membership fee. The pamphlet should prove of great value as an inducement to central stations to join the association.

A number of letters are also being sent out, the arguments being sound and logical, so that they should prove effective. One interesting point is that, while by the last census 231 cities and towns had 25,000 population, the association has an active central-station membership of 568, so that the votes of the smaller cities and towns control as a company in a city of 1000 inhabitants has its vote count just as much as a company in a large city.

The initiation fee is $25 and the yearly dues $10.

J. Robert Crouse, chairman of the membership committee of the National Electric Light Association, has been doing some excellent work in boosting the membership of the Association. At the meeting of the executive committee May 2d, the following members were accepted:

CLASS A.

The Central Colorado Power Company, Colorado Springs, Col.

Pike's Peak Hydro-Electric Company, Colorado Springs, Col.

The Torrington Electric Light Company, Torrington, Conn.

Cairo Electric and Traction Company, Cairo, Ill.

Ligonier Electric Light Company, Ligonier, Ind.

People's Light and Power Company, Indianapolis, Ind.

St. Clair Edison Company, Mt. Clemens, Mich.

Eveleth Electric Company, Eveleth, Minn.

Le Roy Hydraulic Electric Gas Company, Le Roy, N. Y.

Rockland Electric Company, Hillburn, N. Y.

Buffalo Manufacturing Company, Buffalo, Wyo.

Compañia de Gas y Eléctricidad, Havana, Cuba.

Jasper Water, Light and Power Company, Jasper, Ala.

Pend d'Oreille Electric Company, Sand Point, Ida.

Abner Driver, Osceola Lighting Plant, Osceola, Ark.

The Skagit Improvement Company, Sedro-Woolley, Wash.

The Circleville Light and Power Company, Circleville, O.

CLASS B.

P. H. Bartlett, The Philadelphia Electric Company, Philadelphia, Pa.

Samuel T. Cooper, The Philadelphia Electric Company, Philadelphia, Pa.

A. R. Cheyney, The Philadelphia Electric Company, Philadelphia, Pa.

J. M. Eglin, The Philadelphia Electric Company, Philadelphia, Pa.

Geo. Ross Green, The Philadelphia Electric Company, Philadelphia, Pa.

H. K. Mohr, The Philadelphia Electric Company, Philadelphia, Pa.

D. Fred'k Schick, The Philadelphia Electric Company, Philadelphia, Pa.

Edward S. Mansfield, The Edison Elec. Ill'g Company of Boston, Boston, Mass.

L. Springs Montgomery, Mobile Electric Company, Mobile, Ala.

J. W. Ricketts, Oroville Light and Power Company, Oroville, Cal.

F. C. McGonnigle, Youngstown Consolidated Gas and Electric Company, New Castle, Pa.

Paul Kearcher, Youngstown Consolidated Gas and Electric Company, Sharon, Pa.

E. S. Roberts, Escambia County Electric Light and Power Company, Pensacola, Fla.

E. W. Furbush, Gardner Electric Light Company, Gardner, Mass.

Henry H. Taylor, Garned Electric Light Company, Gardner, Mass.

A. L. Selig, The Los Angelos Gas and Electric Company, Los Angelos, Cal.

W. L. Boxall.

B. F. Pearson.

S. M. Kennedy.

Charles A. Tucker, Rochester Railway and Light Company, Rochester, N. Y.

C. N. Pratt.

I. E. Powell.

F. A. Willard.

K. A. Schick.

James T. Hutchings.

CLASS D.

The American Railway Insurance Company, Cleveland, O.

The Franklin Electric Manufacturing Company, Hartford, Conn.

Harold P. Brown, New York City.

Commercial Truck Company of America, Philadelphia, Pa.

The Jandus Electric Company, Cleveland, O.

CLASS E.

L. A. Osborne, The Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.

W. M. McFarland.

W. C. Webster.

G. E. Miller.

C. E. Skinner.

The aggressiveness of the Detroit Edison Company in securing new business by the threefold means of solicitation, advertising and demonstration is shown by the accompanying table covering the years 1905 and 1906.

COMPARISON OF CONNECTED LOAD, 1905–1906.

	Jan. 1, 1905.	Jan. 1, 1906.	Percentage of Inc.	July 1, 1906, 6 Mos.	Percentage of Inc.
Meters, No. of Customers	8,646	11,064	27.9	12,331	22.8
Total connected 16 C. P. equivalents	362,796	450,215	24.1	528,745	34.8
Motors Only:					
Number	1,041	1,398	34.3	1,814	59.4
Horse-Power	5,671	7,528	32.7	10,806	67.8

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31, bis rue de Fauburg Montmartre, Paris

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J. H. SMITH, Editor

Editorials

Leading Articles

The Moore Light

THE idea of generating light directly from gases, as suggested by the late Professor Langley in his historic investigation into the energy of various forms of light, is bearing fruit twenty years after the original laboratory work. Three separate investigators, Steinmetz, Cooper Hewitt and Moore, have been attempting the commercial production of light directly from the gas. While the first investigator has read numerous papers before engineering societies, his mercury vapor lamp is still a laboratory device, or at least has not yet given promise of a commercial success to rival the lamp of Cooper Hewitt. We should otherwise have been familiar with its form before this.

The first two inventors have chosen mercury vapor, and Moore, while he has employed carbon dioxide, chooses air, which gives a spectrum not far removed from daylight, and in color is perhaps more pleasing than the yellow incandescent filament.

Much quibbling has been made over its efficiency, but at the present stage of its development this criticism seems untimely. It is enough that the light is more than ordinarily efficient, and is making rapid commercial headway as a luminant.

In the beginning its luminous intensity was low, the power factor was very low, the operating frequency high and commercially impossible. The luminous intensity while still quite low is now one hundred times that of the tube shown in public exhibition in 1898. The power factor has shown a very marked improvement. In tests of a year ago the power factor was .56, while recent tests show a power factor of .75. The apparatus now operates successfully on 60-cycle current.

The cost of the Moore tube is reasonable, being already less than the cost of an incandescent lighting system with the necessary wiring, fixtures and shades. It is not burdened with a renewal charge; at least some of the tubes have been in operation two years without requiring any repairs or "glass plumbing," as the building or repairing of the tube has been facetiously termed.

Ratio of Generating Capacity to Maximum Load

THE maintenance of continuous service is of greater value to a central station than the saving of the interest on the slightly increased capital required to provide reserve generating capacity for maintaining the service in case of accident to some portion of the equipment. The interest on capital thus expended may be considered as the premium on an insurance policy covering the loss of custom due to an interruption in service.

When the lights go out on the premises of a customer or the motors stop in his factory, he is sure to send in a complaint, and justly so, for he knows the value of his loss in dollars and cents. The merchant knows the value of one night's lost trade and the manufacturer knows the value of a day lost in producing finished material; the amount in either case will likely be greater than the cost for producing light or power for the entire year. It is therefore necessary for all large central stations to provide a certain amount of reserve capacity to produce the load during times of disablement of part of the equipment.

Small stations, below 500 kw., do not permit of a division of generators to obtain sufficient overload capacity from the remaining generators when one generator becomes disabled. There are two reasons for this, which are: first, the increase in cost for the entire station, for a large number of small units is greatly in excess of the cost for a lesser number of larger units; and second, a small generator heats quickly with increase of load. Peak loads last from two to three hours and small generators will not carry sufficient overload for this period to allow of eliminating one machine.

Take as an example a distributing system of 300 k.w. maximum load. A standard generator capacity is selected from those proposed by the different manufacturers. For a station of 300 k.w. capacity, three 100 k.w. generators would be a good selection, and, if there is indication of an increase in business, the power station had best be built of a size to accommodate a fourth generator with its motive power. It would not be safe to force two of these generators to carry the peak load for more than one hour; they would be overloaded 50 per cent. A better selection of generators would be three of 150 k.w. capacity each. By estimating the cost for the entire station, boilers, engines and generators, it will be found that the total cost for the three 150 k.w. generators is not greatly more than the cost for three 100 k.w. generators and will be less than the cost for four 100 k.w. generators.

Stations of moderate capacity, from 500 k.w. to 5000 k.w., permit of a division of generators to obtain sufficient overload capacity from the remaining generators when one generator becomes disabled. Generators, boilers and engines cost about in proportion to their output when of moderate size, and many generators of moderate size will carry large overloads for from two to three hours. Overload capacity of all large electric apparatus depends to some extent on the amount of material to be heated. Heating of generators is caused by heating in the iron due to iron loss, hysteresis and eddy currents, and heating in the copper due to resistance. At times of overload, the iron loss is not more than at times of normal load, while the copper loss increases as the square of the overload. As long as the iron remains cooler than the copper, heat is transmitted from copper to iron. This transfer of heat continues until the entire mass is approximately of uniform temperature and requires time to raise the temperature to a dangerous point.

For a station of 4000 k.w. maximum load, four generators of 1000 k.w. capacity each would give good results. In case of accident to one unit, the three remaining generators will usually permit of forcing to their overload capacity for a sufficient period to take care of the overload. Such a condition of affairs is only advisable where the capital is limited to the smallest amount permissible and where the peak load does not continue for more than three hours at the most. Also, the load, during the greater part of the day, must be small enough to allow the generators time to cool.

Engines should be selected of a size to drive these generators at 25 per cent. overload. By this is meant that the range of the engine governor should be sufficient to govern the cut-off at this load and the engine parts must be strong enough to withstand the stresses set up by this overload.

Steam piping is best laid out with one large main taking steam from all the boilers and supply all the engines, with valves between each pair of boilers and engines; a leak in any part of the piping can be repaired by shutting off the section affected. Where the space available for the station depends on fixed boundaries, as when the engine room is built with two dimensions about equal, the steam header may be looped around the engine room to advantage. The looped steam header takes steam from each boiler and supplies steam to each engine in two directions, giving additional security from the shut-down of any one unit when leaks develop.

A reserve capacity of boiler heating surface over that necessary for generating the steam required by the engines is a necessity on account of frequent cleaning. Some misunderstanding is caused by the present method of rating boiler horse-power on the basis of 30 pounds of steam at 70 pounds pressure, evaporated from feed water at 100° F.

Small engines have a steam economy of about 35 pounds of steam per hour non-condensing, and as low as 15 pounds when compound and exhausting into a condenser. The engine economy must be known before the size of boilers can be determined. Allowing 90 per cent. efficiency for the generator and 10 per cent. friction for the engine, the indicated horse-power of the engine driving a generator on a 1000 k.w. load is 1660 i. h. p. Suppose the engine economy to be 20 pounds of dry steam per hour at 150 pounds pressure, and that part of the exhaust steam is used to heat the feed water to 200° F. By consulting a steam table, this steam economy is found to equal 18.5 pounds of steam on the same basis as the boiler rating. The 1660 i. h. p. at the engine requires 1025 boiler h. p. A battery of two 500 h. p. boilers answers the requirements for one engine, but for the emergency of cleaning. Boilers, however, admit of forcing when of sufficient grate area for the grade of coal burned and when the chimney is of large size. Ample resources for producing a strong draft either by means of power-driven fans or with a large chimney give best results for caring for boiler overloads.

When considering the boilers for any particular station, the time overloads are carried must be taken into account. Traction systems operating a few heavy trains frequently drain the boilers of steam, causing the pressure to fall, which in turn increases the steam for a given i. h. p. at the engine. It is therefore necessary that boilers have a large steam capacity to care for momentary overloads.

Stations of large capacity, above 5000 k.w., usually supply a class of service that must be supplied continuously. Close scrutiny of detail plans of a large station will frequently show some part of the equipment the failure of which would cause the shut down of the entire station. This part of the equipment may be the source of feed water supply, feed pipes, feed pumps, coal supply, coal conveyors, condensers, exhaust piping, air pumps, steam piping, electric cables, switchboard connections or the fittings of any of these items. Large stations are constructed for the purpose of centralizing power production and great care must be exercised lest, in thus centralizing the power generating equipment, the failure of some auxiliary that is ordinarily unimportant will cause an entire city to be deprived of light and power.

The unit for large stations is 5000 k.w., with a tendency toward the 10000 k.w. unit, the latter size being made possible by the introduction of the steam turbine. For a station of 25000 k.w. capacity, six 5000 k.w. generators, with motive power, is the only desirable selection, reserve capacity being provided for by the sixth unit.

One main steam header for supplying the entire station would necessitate a pipe of such length that it would be impossible to take up the expansion and contraction caused by variation in temperature. Steam headers should be kept full of live steam at working gauge pressure, but this is not always convenient, so that times will occur when the header contracts from a reduction in temperature. The large plant is divided into several complete small plants contained by one building, these plants being cross connected with piping to equalize the load.

When the estimates for a station of this size are made from actual proposals of manufacturers, the saving derived by the installation of steam turbines is shown to be so great that other motive power will not be considered. The only question is the relative merits of the vertical and horizontal types of turbines. The vertical turbine requires slightly less floor space than the horizontal type, which advantage is offset by an increase in height of building. The horizontal turbine has a very decided advantage, due to the normal position of the bearings and ease of access to all parts.

Operating electric companies cannot afford to provide more than one unit for reserve capacity. Traction companies invest such large capital for the complete system that the cost of the power station is comparatively small. The traction companies are, therefore, willing to authorize a large expenditure to insure continuity of service, the importance of maintaining the service having been found so desirable in one instance as to authorize the building of two stations, either of which can take care of all demands on the system. The increase in fixed charges for duplicate stations may not affect the total by more than one per cent.; this amount becomes large, however, when the difference between a five per cent. and a six per cent. dividend is shown, which is further evidence of the immense importance of reserve capacity.

The numerous lighting companies, which are considering an increase in generating equipment to take care of possible future business, whose generators are already forced to large overloads during the long days of the year, would profit by comparing some of the modern stations lately built with the load they are expected to supply.

Some Developments in Sub-Station Design

NOWHERE more than in large cities, where direct-current distribution for lighting and power service makes the establishment of substations necessary, does this part of a distributing system require thought and care in its design. In the first place real estate is at a higher figure than in localities where railway substations may be built, and hence the end sought is to obtain as high a capacity per square foot as possible.

In one large city substations built within the last few years have averaged from 2 to 2.6 k. w. per square foot, but the development in this regard may be shown by the fact that one of the very recent stations has a capacity of 3.5 k. w. per square foot.

The use of concrete for buildings has extended to substations and power-stations, the successful results obtained with this construction for manufactories having demonstrated its fitness and reliability. Not the least part of the concrete in a substation, of course, is that for the switch compartments, formerly built of brick or slate.

One of the interesting developments in the equipment of the substation, concerning which, however, but little has yet been made public, is the design of a rotary converter having as an integral part a device which takes the place of the induction regulator.

Whatever this device may be, and however it may stand up in practice, it will yet be welcomed as an attempt in the direction of simplifying the somewhat complicated equipment of the rotary-converter substation.

Another hint as to coming simplicity was given by W. J. Wilgus in discussing F. J. Sprague's paper at the recent meeting of the Institute. In dealing with this question of simplifying equipment, Mr. Wilgus mentioned "a device which will cost very little, will take the place of the rotary converter and require no attendance"—rather a vague statement. Can it be that the battle between alternating current and direct current for railway operation is to be decided by the advent of a rival to the transformer?

Low Power-Factor Loads

FOR the same number of true watts delivered, a low power-factor load does not take a different amount of fuel from a high power-factor load, but it requires a larger investment on account of the heavier machinery required. Thus, at Niagara Falls, where fuel is practically free and the investment is enormous, and the customers are large users, some of the companies put in graphic recording power-factor meters so as to penalize the customer who takes his power at a low power-factor. Such a system of charging, while complicated, is otherwise reasonable, both in the water-power plant and in steam plant where the cost of the investment is large as compared with operating expense.

One of the Niagara power companies in its agreement for the sale of electric power inserts the following clause:

"The purchaser shall at all times take and use the three-phase power in such manner that *the power-factor will be as near* 100 *per cent. as possible;* but whenever it is not possible to take the current at 100 per cent. power-factor and the power-factor is less than 90 per cent., then the maximum demand for power shall be considered as 90 per cent. of the maximum kilovolt-amperes taken for a period of one minute each day, except as hereinbefore provided that the maximum demand shall in no case be considered as less than the firm horsepower hereinbefore agreed to be taken and paid for."

Another way of compensating the operating company for a low power-factor service is to multiply the real load by $\frac{.9}{x}$ where x is the average power-factor when below .9.

In reply to an inquiry whether a central station should make a charge based upon low power-factor, one of the leading central station managers has written as follows:

"Theoretically, I believe that the absolutely fair way to do would be to charge not only for the real load of the alternating-current motor, but also to make some fair charge for what you term the apparent load required in the way of additional investment in electrical machinery and lines, in cases where the power-factor is low or is below unity. For while the operating costs and the investment from the steam engine back to the real estate will follow the real load, the electrical investment will follow the apparent load. In practice it is very difficult to find any method to accomplish this. I believe the tendency on the part of some operators of plants is to charge on the basis of the real load."

A power load of low power-factor, which for the sake of illustration we will place at 50 per cent., means that the actual energy delivered to the load is 50 per cent. of the volts times amperes, or the apparent load. The actual energy required at the engine cylinder is the 50 per cent. indicated, but the amperage flowing on a constant-potential system at 50 per cent. power-factor is equal to twice that necessary to deliver the same energy at unity power-factor; and as the capacity of the generating transformer and conducting apparatus is directly affected thereby, and, as the voltage drop and the regulation of these are more severe at a lower power-factor, it is to be seen that the electrical part of the system is operating under all the stress of the full load. Even the steam economy is affected when the ampere load of the generator is such as to require three generators with three engines to carry what would ordinarily be the full load for two generators with their engines, a load which at unity power-factor could be easily carried by two.

As another illustration, assume two shops, each with 50-horse-power average load, one of direct-current motors supplied from a motor-generator set and the other from small induction motors. These average conditions might easily obtain:

Case I.—Direct-current, k. w. connected, 75; average load, 50-horse-power, 37½ k. w.; motor-generator set efficiency, 72 per cent.; motor-generator set input, 52 k. w.; synchronous motor-generator set input, 52 k. w. at 100 per cent. P. F.; induction motor-generator set input, 90 per cent. P. F., 58 k. v. a.

Case II.—Alternating-current, k. w. connected, 75; average load, 50-horse-power, 37½ k. w.; average power-factor, 65 per cent.; average input, 58 k .v. a.

Assuming an input to the motor-generator set in Case I and motors in Case II of 58 k. v. a., it is readily seen that the transformer capacity required in each case is the same, 60 k. w.

The same investment is required for each service until the prime mover is reached. Here, neglecting losses, one customer requires 37½ k. w. of energy, the other 52 k. w.

Assuming both of these shops to run ten hours a day, one shop would consume 375 units a day, equivalent to a five-hour use of the connected load, the other 520 units a day, or a seven-hour use of the connected load.

Naturally the seven-hour user would be entitled to a better rate than the five-hour user, but this would hold true if both installations had the same power-factor.

If, however, besides the wattmeters, a Wright demand meter measuring ampere maximum were installed, and the rate earned fixed upon the hours' use of maximum kilo volt-ampere demand the charge would be more equitable to both consumer and central station.

Suppose in each case the maximum demand were 125 per cent. of the average and that the power-factor of the motor-generator set came up to 92 per cent. at this demand, while that of the alternating-current motors came up to 70 per cent. at that demand.

The maximum demand in Case I becomes 52 x 1.25—.92=70.7 k. v. a. and in Case II 37½ x 1.25—.7=67.0 k. v. a.

The hour's use becomes 520—70.7 =7.35 as against seven hours, and in Case II 375—67=5.60 as against five hours.

If a leeway of from 100 to 90 per cent. power-factor were allowed, the product of $\sqrt{3}$ by the maximum amperes by the voltage could be reduced 10 per cent. and used as a figure from which the hour use was to be divided.

Graduating the Thickness of Wire Insulation

WE print below a letter in which Mr. Del Mar replies to several of his critics who suggest that his method does not take account of the increased probability of flaws in larger sizes of wires.

To the Editor:

Several friends who have read the writer's suggested method of graduating the thickness of wire insulation have stated that this method neglects a factor of some importance which will considerably modify the results. This factor is the increased probability of flaws in the insulation of larger sizes of wire, which they say should require less dielectric strain to be applied to larger wires than to the smaller, in order to cause a breakdown. This matter was considered by the writer when formulating the method in question, and was put aside on grounds which are illustrated by the following analogy.

Consider a steel bar, of one-inch diameter, which will break under a stress of 50,000 lbs. per square inch. According to the reasoning recommended by my friends, a steel bar of two-inches diameter will break under a stress less than 50,000 lbs. per square inch, on account of the greater chance of imperfections due to its greater size.

This would undoubtedly be true if the average of tests were taken on every bar made in the mills. If, however, only bars without flaws are selected, the largest bars should show the same tensile strength as the smallest. Hence, if flawless bars are required, it is essential that the full tensile strength test be met in every case.

Applying this reasoning to the case of rubber insulation submitted to a dielectric stress, if flawless insulation is required it must pass the same dielectric stress test regardless of the area of insulation exposed.

From the point of view of the manufacturer, of course, it is desirable to graduate the dielectric stress according to the size of wire, in order to pass the same proportion of large as of small wires out of the total manufactured. The manufacturer will, therefore, display great anxiety to have the dielectric stress graduated according to the size of wire. Users of rubber insulated wire, on the other hand, want just as good material in the large wires as in the small, and should therefore require the insulation to be sufficiently perfect to stand the same dielectric stress as the smaller sizes.

It should be noted that the safety factor recommended in my article is from 3½ to 7, which is not far from that used for steel bars mentioned above when used for structural work.

Yours truly,

WM. A. DEL MAR.

Direct-Current Feeder Calculations for Railways

ALTHOUGH the above title refers only to direct-current feeders, the general principles involved are equally true for alternating-current railway feeders, the modifications necessary to apply these formulæ to alternating-current systems being obvious.

POTENTIAL DROP.

The total drop of potential in the positive and negative conductors is governed by four conditions, namely: the possibility of starting the cars, the brilliancy of the lights, the limiting of drop in the grounded conductors and the relative economy of low first cost compared with low energy loss. With regard to the question of starting the cars, the voltage required may be derived from a study of the motor curves.

With the multiple-unit system of control, the limiting voltage is usually that at which the contactors will operate satisfactorily, this being about one-half the normal running voltage. The voltage at which the car lights become too dim is about 90 per cent. of the rated voltage of the group of lamps. As, however, these are usually rated considerably below the normal bus voltage, it is permissible to let the voltage drop more than 10 per cent. without affecting the lights too seriously.

The drop in grounded conductors is usually covered by city ordinances, which require it not to exceed a specified amount.

The investment in a system of conductors may be expressed as an initial cost or as an annual interest thereon. The value of the kilowatt-hours of energy lost in these conductors is most conveniently expressed as an annual expense. The sum of these two annual items is the total annual expense of the feeders, which it is desirable to make as small as possible.

AUXILIARY FEEDERS.

Any direct-current feeder system consists of two distinct parts, the conductors which supply current from the power-house to the line and the contact conductors which yield their current directly to the cars. In many cases the contact conductors will be sufficiently large to fulfil both functions, but more often they are supplemented by auxiliary copper feeders. The various steps at which auxiliary copper may have to be added are given below in the order in which they usually have to be treated.

I. If the drop in the grounded conductors exceeds the legal limit or the limit prescribed by danger of electrolysis, copper will have to be added to these conductors.

II. If with this additional copper the total drop in the positive and negative feeders is still too great to enable the cars to start, additional copper must again be resorted to, but this time it may be added to either the positive or negative system. Whether it will be more economical to add it to the positives or negatives will have to be worked out for each case, although an indication is given by the fact that if the unit price of conductors installed is the same for both, it is more economical to distribute the copper so as to make the resistance of the two systems equal.

III. Having provided copper to maintain the voltage high enough to start the cars, it remains to determine whether it is also high enough to keep the lamps bright. If not, more copper must be added in the way described above.

IV. The feeder system having been made of ample dimensions to meet all the conditions of the service, it remains to determine whether the annual loss in the conductors is great enough to justify the addition of more copper in order to keep down the operating expenses. If the conductivity is sufficient, there is nothing to be done; but if the considerations of operating economy call for more copper, the engineer is justified in recommending it.

In order to determine the most economical copper investment, it is convenient to compile a table showing the following six quantities: (1) Value of proposed additional conductors. (2) Total annual energy loss (kilowatt-hours) in the entire positive and negative system, including the proposed additional conductors. (3) Value of this lost energy. (4) Value of the additional conductors. (5) Annual interest on value of additional conductors. (6) Sum of value of total annual energy loss and the interest on proposed additional conductors. When selecting the figures for the first column two values should be assumed initially and all the other columns worked out for them, in order to give an indication of the range of values which is most convenient to work with.

DISTRIBUTION OF CURRENT.

A certain current passing from the positive to the negative system at the end of the line farthest from the power station being assumed to cause a total drop of V volts, the same current divided up between n equidistant points along the line will produce a total drop of $(1 + \frac{1}{n}) \frac{V}{2}$ volts. If n is infinite, that is, if the drain of current is uniform along the line, the drop will be $\frac{V}{2}$ If, however, n is not infinite, the drop will be greater than $\frac{V}{2}$ by $\frac{100}{n}$ per cent., a quantity which is quite small when n is considerable. It is therefore usual to assume a uniform drain of current, a proceedure which is further justified by the continuous motion of the load which causes it to act as if more distributed.

Such an assumption, however, is by no means justifiable on interurban or trunk line railroads, as in such cases the trains are usually far apart. In such cases the train diagram should be consulted in order to find where the greatest load occurs at any time, and the drop calculations made for the magnitude and location of load thus found.

DISTRIBUTION OF COPPER.

The drop of potential depends largely on how the additional copper is distributed along the line. It is therefore important to secure the most economical distribution of copper which will give the required drop. The auxiliary copper may be connected to the contact conductor at such frequent intervals that it virtually forms a part of it; it may, on the other hand, be connected at one end only, or it may be connected at such distances as not to be covered by either of the above cases. Each of these schemes requires separate consideration, a general method of treatment being given for each, which covers the addition of copper to either the positive or negative system as the case may require.

AUXILIARY COPPER FREQUENTLY CONNECTED.

The diagram in Fig. 1 shows the most economical way of distributing the feeder metal with the formuke for circular mils volume of copper, watts lost and potential drop. The following symbols are used in both Figs. 1 and 2.

C.M. = Circular mil, the area of a circle of $\frac{1}{1000}$ inch diameter.

x_1 = distance E D, & y_1 = C.M. of copper in E D.

x_2 = distance E C, & y_2 = C.M. of copper in D C.

x_3 = distance E B, & y_3 = C.M. of copper in C B.

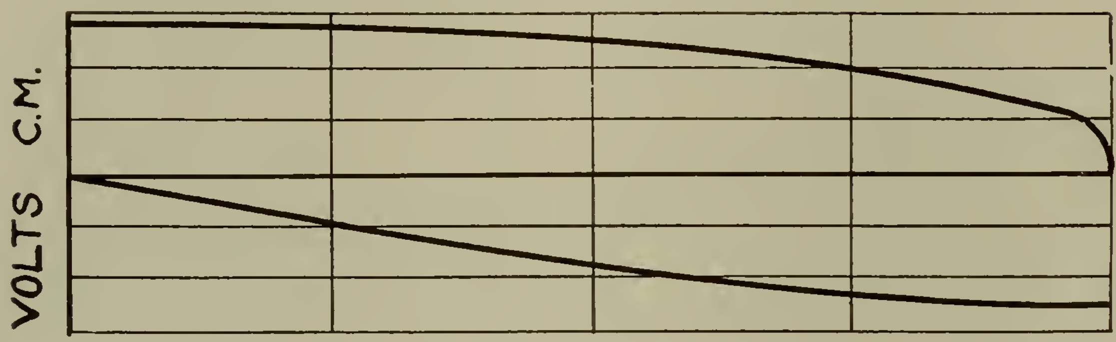

FIG. 1.

C.M.-Ft. = Circular mil-feet, the volume of a cylinder of one C.M. area and one foot long. A volume of copper in C.M.-Ft. divided by any number of C.M. gives the number of feet of cable of that area required to make up the given volume of copper.

r = The resistance of a C.M.-Ft. of copper, measured along its length.

x_4 = distance E A, & y_4 = C.M. of copper in B A.

$$\text{C. M.} = \frac{2}{3}\, r \cdot \frac{A}{V} \cdot \sqrt{L} \cdot \sqrt{x}$$

$$\text{C. M.} - \text{feet} = \frac{4}{9} \cdot r \cdot \frac{A}{V} \cdot L^2$$

$$\text{Drop} = \frac{V}{\sqrt{L^3}} \cdot \sqrt{x^3}$$

$$\text{Watts lost} = \frac{3}{5} AV$$

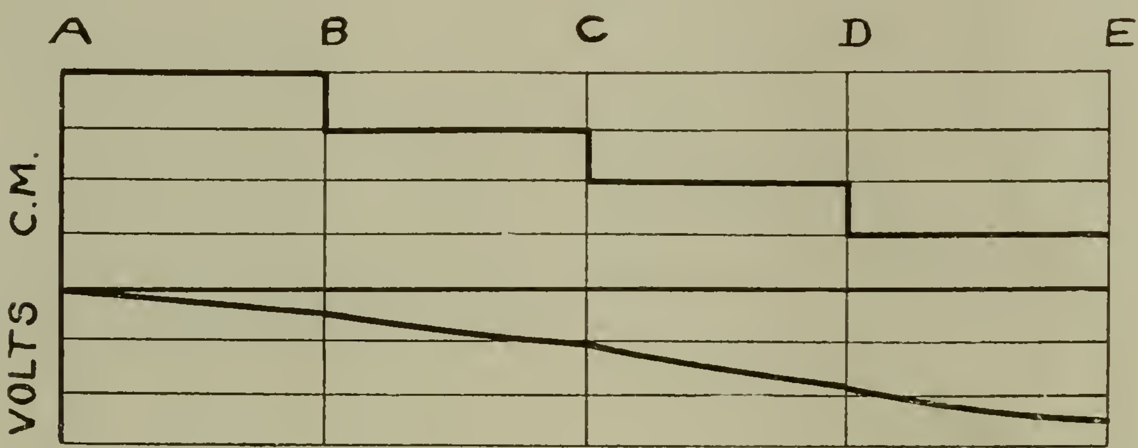

FIG. 2.

r = 10.3 for copper of 100% cond.
10.4 for copper of 99% cond.
10.5 for copper of 98% cond.
10.6 for copper of 97% cond.
10.73 for copper of 96% cond.
10.85 for copper of 95% cond.

If the conductors are partly of iron, as with a third rail, it is usual to reduce the area of iron to its equivalent area of copper.

V = Drop of potential from the station bus to the end of the line in either the positive or negative conductors, as the case may be.

A = Total current delivered from the station bus to the section under consideration.

L = Length of the section, feet.

x = Distance (feet) of any point from the end of the line farthest from the station.

$$k = \frac{1}{2} \cdot r \cdot \frac{A}{L}$$

The drop given by the above formula is from the far end of the line. The drop from the station end may be obtained by substracting this value from V*.

$$\text{Drop in DE} = k\,\frac{X_1^2}{Y_1}$$

$$\text{“ “ CD} = k\,\frac{X_2^2 - X_1^2}{Y_2}$$

$$\text{“ “ BC} = k\,\frac{X_3^2 - X_2^2}{Y_3}$$

$$\text{“ “ AB} = k\,\frac{X_4^2 - X_3^2}{Y_4}$$

Total Watts lost =

$$\frac{1}{3} \cdot r \cdot \frac{A^2}{L^2} \sum \frac{1}{Y_2}\left(X_2^3 - X_1^3\right)$$

It is, of course, impossible to exactly realize the most economical distribution in practice, so that a series of steps, as shown in the second diagram, should be arranged so as to approximate as closely as possible to the theoretical curve. It should be remembered that the curve of most economical distribution shows the total feeder metal, including the contact conductors.

AUXILIARY COPPER CONNECTED AT END.

The auxiliary feeder, in this case, being merely a uniform conductor with the same current along its entire length, may be treated by Ohm's law in its simplest form. Auxiliary conductors of this sort are useful in connection with grounded returns in which it is desired to minimize the drop. Two or more insulated conductors of equal resistance, connected to the line at various points, will each take off their proportion of the current without making the entire current accumulate near the station, as would be the case with a single connection direct from the bus. This gives rise to a series of rises and falls of potential along the line, but there will be no serious drop in the grounded conductors, wherever there may be in the insulated feeders connected thereto.

FEEDERS INFREQUENTLY CONNECTED.

This condition occurs where a feeder cable runs parallel to the line and is tapped in at intervals through circuit breakers or switches. The expense of the breakers renders it necessary to have as few such connections as possible. Fig. 3 shows an example of such a system, comprising four conductors, some of which may be contact conductors and others auxiliary feeders. Fig. 4 shows this scheme is a diagrammatic form, the two generating stations being united on account of their identical influence. Corresponding points in Figs. 3 and 4 are indicated by identical letters.

Let,

l = distance from A to B, expressed in thousands of feet.

R = resistance in ohms per thousand feet, of contact conductor A B.

x = distance from A to L, expressed in thousands of feet.

r = effective resistance in ohms per thousand feet of track H I.

c = resistance (ohms) from A to E.

d = resistance (ohms) from B to E.

e = resistance (ohms) from C to D.

f = resistance (ohms) from H to F.

g = resistance (ohms) from I to F.

Rx = resistance (ohms) from L to A.

R (l—x) = resistance (ohms) from L to B.

rx = resistance (ohms) from G to H.

r (l—x) = resistance (ohms) from G to I.

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*Electrical World, Aug. 29, 1903. Feeder Calculations for Direct Current Railways, by W. A. Del Mar.

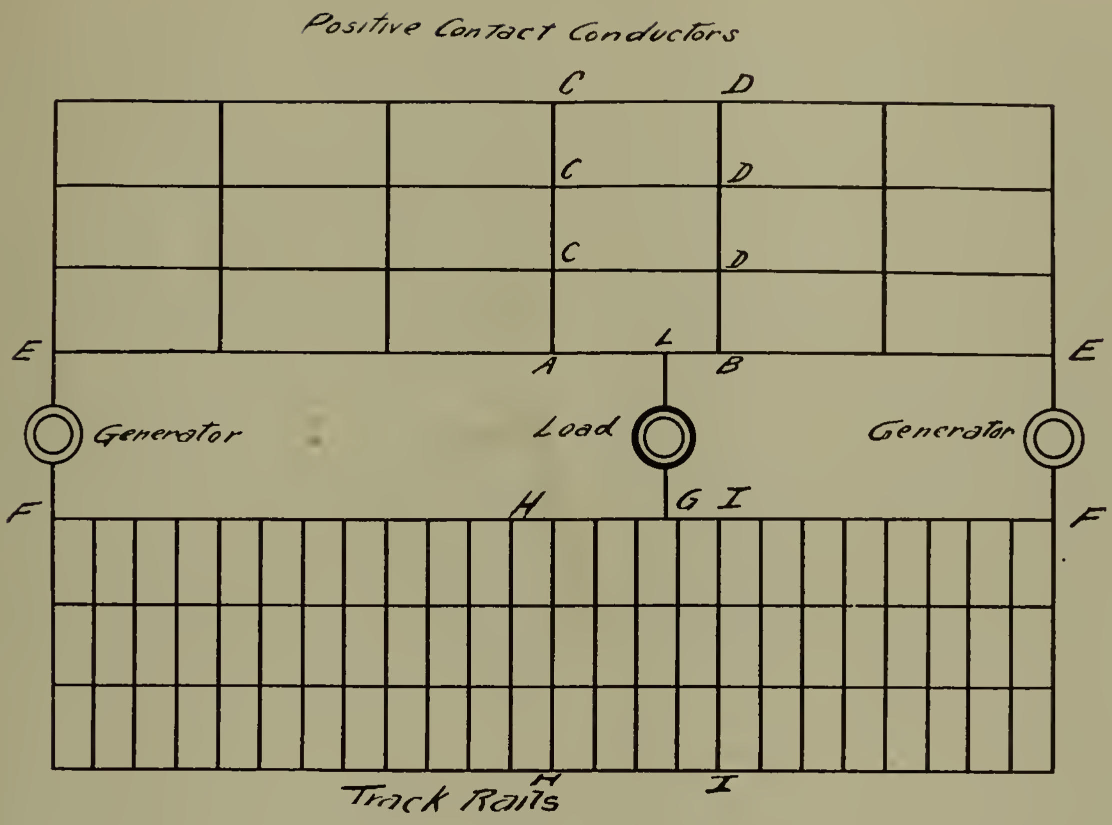


FIG. 3.

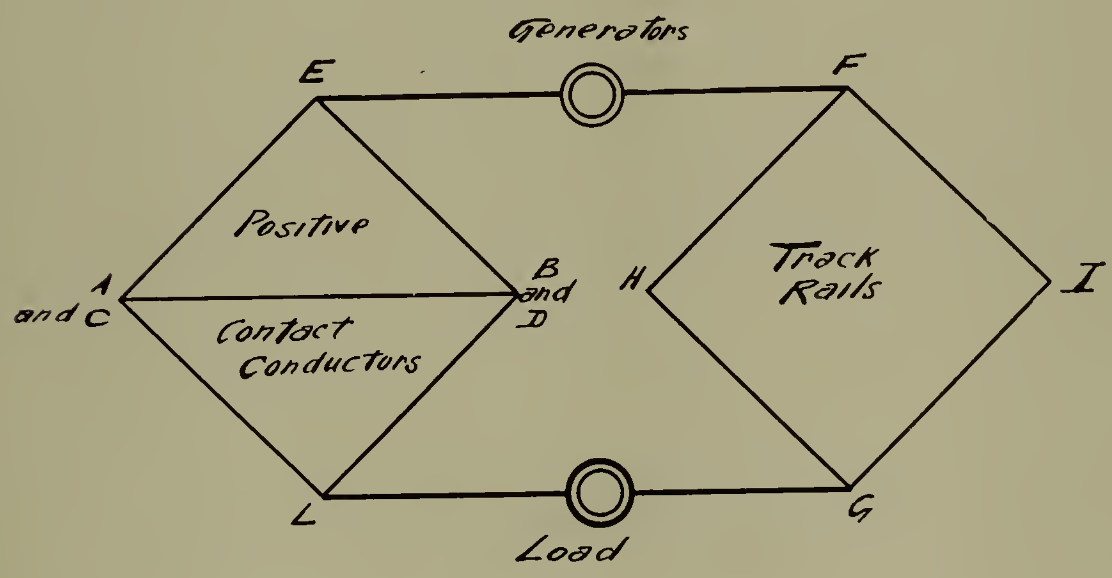


FIG. 4.

The resistance L to E, equals

$$Ax^2 + Bx + C$$

$$\text{where } A = -\frac{RD}{lD+c+d}$$

$$B = \frac{R(lD+d-c)}{lD+c+d}$$

$$C = \frac{c\left\{Rl\left(\frac{d}{e}+1\right)+d\right\}}{lD+d+c}$$

$$D = R\left(1+\frac{c}{e}+\frac{d}{e}\right)$$

The resistance G to F, equals

$$Ex^2 + Fx + G.$$

where,

$$E = -\frac{r^2}{rl+g+f}$$

$$F = \frac{r(rl+g-f)}{rl+g+f}$$

$$G = \frac{f(rl+g)}{rl+g+f}$$

The total resistance in positive and negative feeder systems from load to station, equals

$$Hx^2 + Ix + J$$

where

$$H = A + F$$
$$I = B + F$$
$$J = C + G$$

A more practical expression for the total resistance is given later.

The resistance G to F is a maximum when

$$X = \frac{-B}{2A} = -\frac{1}{2}\left(1+\frac{d+c}{D}\right)$$

The total positive and negative feeder resistance is a maximum when

$$X = -\frac{KNR+MLr}{2\{PNR^2+Lr\}}$$

where

$$K = lRP + d - c$$
$$L = lRP + d + c$$
$$M = rl + g - f$$
$$N = rl + g + f$$
$$P = 1 + \frac{c}{e} + \frac{d}{e}$$

Having found the value of x such that the total resistance is a maximum, *the total resistance* is given by

$$(R = \frac{1}{LN}\{Sx + V - Tx^2\}$$

where $S = KNR + MLr$,

or the numerator of the expression for x;

$$T = PNR^2 + Lr$$

or half the denominator of the expression for x;

$$V = Nc\left\{Rl\left(\frac{d}{e}+1\right)+d\right\} \times Lf\frac{(M+N)}{2}$$

While the expressions in the above formulæ appear somewhat cumbersome, the actual working out of a numerical case is not tedious if a slide-rule is used.

If there are several trains between the two substations, the maximum drop in the section will be the sum of the drops computed for each train as if it were the only one on the line, and the trains should be distributed so as to give the worst condition that would arise in practice.

MISCELLANEOUS FORMULÆ.

The potential drop in any uniform conductor in which the current varies along its length, is given by

Volts = ohms per ft. × area of current curve in ampere-feet.

The watts lost in any conductor along which there is a uniform drain of current are given by,

Watts lost = amperes per foot × area of drop curve in volt-feet.

If a curve of potential drop in any feeder system be plotted for one load, the drop curve for any other load may be derived from it by merely changing the ordinates in the ratio of the two loads in question.

SPACING OF CROSS-BONDS OR EQUALIZERS.

The proper spacing of cross-bonds between tracks, or of any other equalizing connection between conductors, is settled by the following considerations. Let,

w = ohms per ft. per conductor;
D = total length of line, feet;
t = number of conductors cross-bonded, *e. g.*, number of track rails;
n = number of cross-bonds in distance D;
R = resistance, ohms from a point most distant from the station.

Then,

$$R = Dw\,\frac{\frac{n}{t}+\frac{1}{2}}{n+\frac{1}{2}}$$

If it thus be plotted as a curve by taking various values of *n*, it will be found that there is a certain approximate value of *n* beyond which very little decrease of R is attainable by increasing *n*.

The most desirable value of *n* is usually the smallest value that will effect equalization, and is therefore taken where the curve just begins to be practically parallel to the axis of *n* as shown in Fig. 5.

CURRENT VALUE USED IN FEEDER CALCULATIONS.

Assuming nearly uniform drain of current:

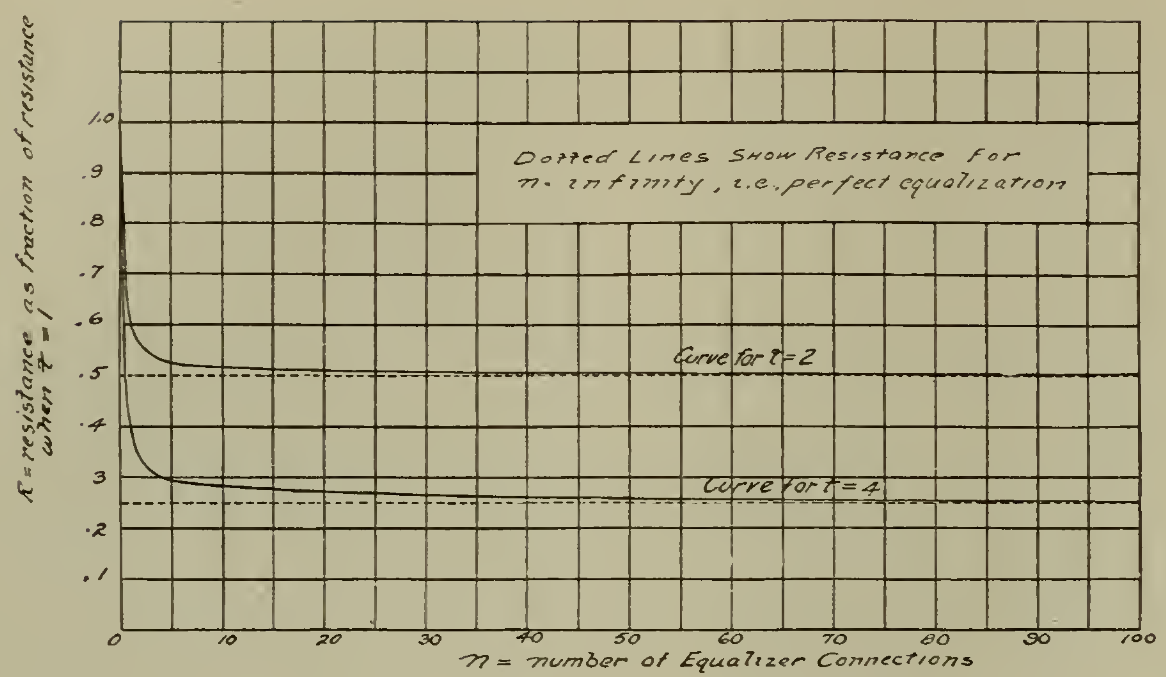


FIG. 5.

Electrolysis.—Average current during hour of maximum load.

Car starting.—Average current during, say, half minute of maximum load.

Lights bright.—Square root of the mean of the current squared during hour of maximum load*.

Copper economy.—Square root of the mean of the current squared over the year.

Heating of cables.—Square root of the mean of the current squared over half hour of maximum load*.

Assuming infrequent train service:

Electrolysis.—The train diagram for hour of maximum load to be used. This will give the load at any time. If a drop curve is made for the load at intervals of, say, five minutes, a curve of average drop may be made therefrom.

Car starting.—The average current during, say, the half minute of maximum possible load assumed to be in the most disadvantageous position.

Lights bright.—Cannot be calculated with a useful degree of accuracy, as the lights will be bright except when there is a specially large current.

Copper economy.—Calculation impracticable. Loss in copper will, however, be greater than if load is assumed to be uniformly distributed, and less than if assumed to be concentrated in the most disadvantageous way. The actual copper loss will therefore be between these extremes.

Heating of cables.—The trains being far apart, it is useless to average the square of the current over one half hour. Five minutes should be ample time.

COST OF ENERGY.

The cost of producing energy in a power station may be divided into two items.

Fixed charges, which are independent of small variations of output, and

Operating expenses, which are proportional to the output. This includes fuel, oil, etc.

In feeder calculations, only the latter item should be used, because the fixed charges will exist independent of any saving in line loss, unless the saving is sufficient to make the plant smaller.

*The above represents usual methods of calculation. This takes care of the average illumination, but not the variations. It does not pay to keep down the variations of illumination by putting in feeder metal.

Power Required for Wood-Working Tools

EACH class of industrial motor work has special requirements, and the application of motors to tools which produce much waste product in their operation has led to the manufacture of the enclosed type of motor, in which the moving parts are protected against the entrance of dust, dirt and the machines own waste product. In wood-working establishments, owing to the fact that the enclosed type of motor in fairly constant service runs warm, it has become quite usual not to employ the enclosed motor, but to place an open type of motor in a suitable box or frame. In many cases the surrounding box is of ample size and the motor lay-out is so arranged that a forced draft of air serves to remove collecting sawdust, and keeps the motor's temperature down.

In the disposition of motors, it is now recognized as better practice to have the motors in accessible places upon the floor, rather than upon the wall or ceiling.

The induction motor of the open type is the preferable machine for wood-working establishments, as its use avoids the troubles due to commutation and dirt.

Owing to the fact that wood-working machines are of high speed and light moving parts, and their load usually comes on with a jerk, it is customary to use compound-wound motors throughout the establishment when the source of power is direct-current. It follows easily from the same consideration that it is desirable to use a belt-drive rather than direct connection or a gear attachment.

In displacing a steam engine or other motive power by electric motors it is frequently necessary to make an approximation of the average load for the purpose of fixing the motor load on the generator, or in the case where power is delivered by a central station, in assuring the customer of the amount of current which he will use and pay for. It has been found where the motor drive is individual, or at least in very small groups of motors closely powered to their work, that the average consumption of current varies from $^1/_{14}$ to $^1/_{10}$ of the connected load, though occasionally it will exceed the larger amount. In other words, the average load does not exceed $^1/_{10}$ of the maximum demand.

The given horse-power values are correct for machines using medium hard or soft woods of the sort generally used in wood-working establishments for the making of door and window sills, doors, boxes and wood trim for houses.

As the majority of wood-working establishments are devoted to certain classes of work, those using soft woods seldom use the harder variety, but when they have a small amount of hard wood to put through, the overload capacity of motors will be ample to take care of the hard wood work. It is well to remember also that since the power required by a machine varies directly with its speed, that a less load may be put upon a wood-working machine by not forcing its material through at so fast a rate as with soft wood.

In shops working entirely with the commoner hardwoods, as ash, oak, or walnut, the next standard size above those listed below should be chosen.

Establishments using the very hard woods, such as lignum vitæ, should have all machines equipped with motors of approximately twice the given horse-power rating.

Band Saws.

Band saws are of the endless band style passing over two guide wheels, one above the work and the other below it. They are divided into several classes, according to the nature of the work to be performed, as follows:

Resaws:

- 60″ Wheels ... 30 H. P.
- 54″ " ... 25 "
- 48″ " ... 15 "
- 40″ " ... 7½ "
- 38″ " ... 5 "
- 28″ " ... 3 "

Rip Saws:

- 42″ Wheels ... 10 "
- 40″ " Power Fed ... 7½ "
- 40″ " Hand Fed ... 5 "

Plain Band Saws, suitable for any light work, as scroll sawing, cutting-off, etc.:

- 42″ Wheels ... 3 H. P.
- 38″ " ... 3 "
- 36″ " ... 3 "
- 34″ " ... 2 "
- 30″ " ... 2 "

Circular (Disk) Saws.

Circular Saws are used for a variety of purposes, from making laths to ripping heavy timbers. The swing saw, supported from the ceiling, is the only one not held in a stationary frame.

Resaws:

- 32″ Diameter ... 10 H. P.
- 24″ ... 10 "
- 10″ Stationary ... 3 "

Combination Saws:

- 16″ With Dadoing Attachment ... 3 H. P.
- 12″ " " " ... 3 "
- 16″ Universal Saw Bench ... 5 "
- 20″ Saw Bench ... 5 "
- 14″ " " ... 3 "
- 14″ With Boring Attachment ... 5 "
- 12″ " " " ... 3 "
- 10″ " " " ... 3 "
- 12″ Saw Bench ... 3 "
- 10″ " " ... 3 "
- 24″ Lath Bolter ... 7½ "
- 14″ Lath Mill ... 10 "

Plain Circular Saws:*

- 36″ ... 10 H. P.
- 30″ ... 10 "
- 24″ ... 7½ "
- 22″ ... 7½ "
- 20″ ... 7½ "
- 18″ ... 7½ "
- 17″ ... 7½ "
- 16″ ... 5 "
- 14″ ... 5 "
- 12″ ... 5

Plain Circular:

- 8″ ... 5 H. P.
- 6″ ... 3 "

Swing Saws:

- 36″ to 48″ ... 5 H. P.
- 24″ " 28″ ... 2 "
- 10″ " 14″ ... 1 "

Railway Cut-off Saw:

- 16″ ... 7½ H. P.

*Circular saw sizes refer to largest diameter of saw for given machine.

Jig Saw.

- ¼″ for Scroll Work ... 2 H. P.

Gang Edger and Ripper.
(Refers to Width of Stock.)

- 30″ Power Fed ... 10 H. P.
- 30″ Hand Fed ... 10 "
- 27″ Power Fed ... 7½ "

Edger and Jointing Saw.

- 16″ Saws ... 7½ H. P.

Edging Saw.

- 16′ 1/16″ Saw, Hand Fed ... 7½ H. P.
- 10′ 1/16″ Saw, Hand Fed 16 (1) ... 5 "

Timber Sizer.

- Six or Eight Roll ... 40 H. P.
- Above with lower cylinder cutting first ... 40 "

Planers.

Planer and Matcher:

- 9″ by 8″ ... 15 H. P.
- 14″ " 8″ ... 15 "
- 19″ " 8″ ... 15 "
- 21″ " 8″ ... 20 "
- 24″ " 8″ ... 20 "
- 26″ " 8″ ... 20 "
- 30″ " 8″ ... 20 "
- 30″ " 8″, Twin ... 20 "
- 9″ " 6″ ... 15 "
- 15″ " 6″ ... 15 "
- 24″ " 6″ ... 20 "
- 30″ " 6″ ... 20 "

Planers (or Surfacing Machines):

- 30″ by 6″ to 30″ by 14″ ... 15 H. P.
- 24″ " 6″ " 24″ " 12″ ... 10 "

Planers for Furniture Surfacing (Double):

- 27″ by 7″ ... 7½ H. P.
- 30″ " 7″ ... 10 "
- 36″ " 7″ ... 10 "

Planers for Furniture Surfacing (Single):

- 16″ by 6″ ... 3 H. P.
- 18″ " 6″ ... 3 "
- 20″ " 7″ ... 5 "
- 24″ " 7″ ... 5 "
- 27″ " 7″ ... 5 "
- 30″ " 7″ ... 7½ "
- 36″ " 7″ ... 7½ "
- Slat Planer ... 2 "

Diagonal Planer and Polisher:

- 36″ wide ... 5 H. P.
- 42″ " ... 7½ "

Diagonal Planer:

- 36″ ... 5 H. P.
- 42″ ... 5 "

Jointers and Buzz Planers:

- 8″ ... 1 H. P.
- 12″ ... 2 "
- 16″ ... 2 "
- 20″ ... 2 "
- 24″ ... 3 "
- 30″ ... 5 "
- 36″ ... 5 "

Molders.

Inside Molders:

- 8″–10″ ... 10 H. P.
- 12″ and 14″ ... 15 "

Outside Molders:

- 9″ ... 10 H. P.
- 12″ ... 15 "
- 14″ ... 15 "

Four-Sided Molders:

- 9″ ... 7½ H. P.
- 10″ ... 7½ "
- 10″ ... 10 "
- 14″ ... 10 "

Column Molders:

- 6″ ... 5 H. P.
- 7″ ... 7½ "
- 8″ ... 7½ "

Molders:

- 4″ One Side ... 2 H. P.
- 6″ " " ... 2 "
- 4″ Two Sides ... 3 "
- 6″ " " ... 3 "
- 4″ Three Sides ... 3 "
- 6″ " " ... 3 "
- 4″ Four Sides ... 5 "
- 6″ " " ... 5 "

*Sizes refer to maximum width of stock (as 9″) by thickness (as 6″) it is possible to work into machine.

Molder:

- One-Sided, with and without Grooving Attachment ... 3] H. P.

Tenoning Machines.

- Double Heads, 2 copes ... 3 H. P.
- " " 1 " ... 3 "
- " " No " ... 3 "
- Single " 2 " ... 3 "
- " " 1 " ... 3 "
- " " No " ... 3 "

Double End:

- Single or Double Heads, 2 Copes ... 7½ H. P.
- " " " " 2 " ... 7½ "
- Blind Slat Tenoning ... 2 "
- " " " Hand Fed ... 1 "

Borers.

- Vertical ... 2 H. P.
- " Car ... 5 "
- Post ... 1 "
- Radial ... 2 "
- Horizontal ... 2 "
- Double Chair ... 3 "
- Multiple ... 3 "
- Dowel ... 3 "
- Pin ... 2 "
- Bench ... 1 "

Door Clamps.

- Heavy Screw, Power Fed ... 5 H. P.

Dado Machine.

- 5 Head ... 2 H. P.

Dovetailer and Shaper ... 2 "

- " for Sashes ... 3 "

Rod and Dowel Machines.

- Turns to ⅝″ ... 2 H. P.
- " " 1¼″ ... 2 "
- " " 1½″ ... 3 "
- " " 2″ ... 5 "

Laths.

Automatic Back Knife:

- 40″ Length ... 7½ H. P.
- 50″ " ... 7½ "

Pattern Maker:

- 16″ ... 2 H. P.
- 20″ swing ... 2 "
- 24″ " ... 3 "

Hand Turning:

- 12″ swing ... 1 H. P.
- 16″ " ... 1 "
- 20″ " ... 2 "

Drum Sanders.

Three Drums and Wells:

- 30″ ... 5 H. P.
- 36″ ... 7½ "
- 42″ ... 10 "
- 48″ ... 15 "
- 54″ ... 15 "
- 60″ ... 15 "
- 66″ ... 20 "
- 72″ ... 20 "
- 78″ ... 25 "
- 84″ ... 25 "

Four Rolls:

- 30″, drum ... 3 "
- 36″, 1 " ... 5 "
- 42″, 1 " ... 5 "
- 30″, 2 drums ... 3 "
- 36″, 2 " ... 5 "
- 42″, 2 " ... 7½ "
- Column Sander ... 2 "
- Surface " ... 1 "
- Spindle " ... 1 "
- " and Drum ... 1 "
- Universal Sandpapering Machine ... 1 "
- Disk Sander, Double Disk ... 2 "
- Sand Belt Machine ... 1 "
- Knife Grinder, Automatic ... 2 "
- Ordinary Small Emery Wheel (up to 12″ D) ... 1 "
- Box Board Matcher ... 5 "
- Sash Sticker ... 3 "
- Door Sticker ... 3 "
- Sandpapering Machine ... 2 "
- Rabbeting and Jointing Machine ... 2 "
- Relisher and Wedge Cutter ... 3 "
- " " Mortiser ... 3 "
- Hollow Chisel Mortiser ... 3 "
- Heavy Power Mortiser ... 3 "
- Chain Mortiser ... 2 "
- Mortisers without Boring Machines ... 2 "
- Bit Mortisers ... 2 "
- Blind Stile Mortising and Boring Machine 3 "
- Heavy Variety Shaper ... 5 "
- Two-Spindle Shaper ... 3 "
- Reversible Shaper ... 2 "

Institute Discussion on Electric Trunk-Line Operation

IN opening the discussion on Mr. F. J. Sprague's paper on "Facts and Problems Bearing on Electric Trunk-Line Operation," at the May meeting of the Institute, W. J. Wilgus said that with respect to the conditions that will justify the use of electricity as a motive power in trunk-line operation he believed that *evolution* will govern rather than *revolution.* Railroads, like all other human achievements, cannot stand still; they must either move forward or backward. It is generally recognized that their ability to move forward is now limited with steam locomotive practice, and that the overcoming of the defects inherent to the steam locomotive can only be accomplished with electricity. It now looks as if the first movement in this process of evolution is the substitution of electricity for steam in congested passenger terminals at large centers of population, where the public demand a cessation of nuisances incident to steam locomotives, and where the increasing volume of traffic requires increased capacity that cannot be secured by present motive power. The success of the New York Central installation in both of these particulars is an illustration of what can be accomplished, and imitation will surely ensue at other places where like conditions exist.

Coincident with the change of motive power in crowded passenger terminals, is coming the use of electrically propelled trains on existing steam railroad tracks between large centers of population where frequent units are necessary to accommodate the public. We already have an instance of this in the electrification of the West Shore passenger traffic between Utica and Syracuse, a distance of about fifty miles. In addition to these instances where at this time the wisdom of the adoption of electricity as substitute for steam is self-evident, there are a number of places in the West where the capacity of steam locomotives of the highest type is entirely inadequate to handle freight traffic on the pusher grades, and the only manner in which the increased capacity can be obtained is by means of electricity.

With a start in the substitution of electricity for steam in the operation of congested terminals, connecting lines between large centers of population and long pusher grades with heavy freight traffic, we may look with confidence to a gradual expansion of the use of the new motive power in other directions. For example, in the case of the New York Central the primary object of the use of electricity was to abate the smoke nuisance in the Park Avenue tunnel and increase the capacity of the Grand Central terminal. When this decision was reached it became self-evident that the use of the motive power should extend to the end of the suburban territory at Croton, on the Hudson Division, a distance of about thirty-five miles. While the northerly terminus of the main line is thus planned for the present at Croton, it is probable that just as soon as the developments in the electrical field will warrant such action, the electric zone will be extended as far as Albany, a total distance of 142 miles.

This brings up the question of the respective merits of the three electrical systems now warmly advocated by their respective friends, viz., the direct-current, single-phase alternating-current and three-phase alternating-current. Looking at the matter from an electrical standpoint, it is very much to be deplored that the advocates of each of these systems have seen so much to condemn in the others, as by so doing the steam railroad men have been frightened into a fear of taking any decisive steps when there is such disagreement among those upon whom they must depend for guidance. If, instead of blindly teaching the merits of one system to the exclusion of others, the electrical engineers could unite upon the axiom that each special condition should be carefully studied and the system adopted best suited to it, Mr. Wilgus felt certain that the cause will be further advanced.

For instance, direct-current was adopted for the New York Central installation at New York, among other reasons, because the clearances in the Park Avenue tunnel and the ordinances of the City of New York absolutely precluded the use of overhead construction, and yet we are told that a great mistake has been made and that no other system should have been used but single-phase alternating-current with overhead construction. Entirely apart from any arguments, pro and con, of the relative merits of the two systems, it will be seen that the physical and legal conditions prevented the adoption of any other system than the direct-current.

When there are no limiting conditions and the engineer is free to give full sway to the exercise of his judgment as to the selection between rival methods, the steam railroad engineer first asks, which is the most *reliable.* This question of *reliability* is much more important with a trunk line steam railroad carrying passengers from remote points as well as suburbanites, and mail and express from all over the country, than with local street car systems. For this reason the conservative steam railroad man does not feel like making experiments with untried systems, no matter how alluring their advocates may make them, but prefers a selection from systems which by long tried experience are proved to be thoroughly reliable.

In fact, on the more important trunk line installations, batteries are now felt to be a necessity not only to provide for violent fluctuations of load much greater in range than with ordinary street railroad systems, but also to afford insurance against interruption of traffic due to minor breakdowns in power stations and transmission lines. The New York Central in its desire to secure reliability has not only provided storage batteries, but it has also provided duplicate power stations with access for fuel by both rail and water, either of which, in the event of the disablement of the other, by utilizing spare units and working overload, can run the entire system. Duplicate transmission lines have been adopted for like reasons. Since the commencement of electrical service last December events have already proved the necessity for these precautions.

The answer to this contention that trunk line railroads should use well-tried systems is that no progress can be made unless something is tried. In reply it may be stated that the trunk line railroad is not the place to try experiments, but that interurban roads of minor consequence should be selected and the new system well proved before it is installed on a large scale in territory where its failures may have disastrous results.

Further commenting on the necessity for a study of local conditions, the speaker said that he recently had in his charge the adoption of an electric system for operating combined freight and passenger service through a double-track tunnel now under construction. In view of the claims made by the advocates of different systems, it seemed wise to prepare the specifications so as not to cramp or restrict the best judgment of the competitors, but leave the widest latitude for ingenuity and exercise of skill, consistent with the accomplishing of the desired object. The invitation to domestic and foreign companies, in addition to asking for bids, also requested the filling in of blanks to show the annual costs, including interest charges, depreciation, taxes and operation. The result showed conclusively that for that particular installation, the direct-current system was the cheapest in both first cost and annual cost, to the extent of from 20 to 25 per cent. less than its nearest competitor.

The speaker gave another illustration of the lack of wisdom of making broad generalizations from which to draw specific conclusions. We are often told, he said, that the overhead single-phase system should be used because of the advantage of requiring no substations and substation attendance, but nothing, at the same time, is said about the higher cost of alternation-current locomotives for performing the same service, nor the higher cost of overhead construction as compared with third rail. About a year ago a pamphlet emanating from an eminent authority stated that on four-track trunk line territory overhead construction would cost about $16,000 per mile, when, as a matter of fact, a recent actual installation has cost over $50,000 per mile. Also in a recent installation, while the first cost of the adopted system is somewhat less than one of the rival systems, still the increased consumption of current on one portion of the territory, capitalized, amounts to a very large sum. This amount, added to the cost of installation, brings the equivalent cost considerably in excess of its rival.

The speaker strongly endorsed Mr. Sprague's remarks bearing on the wisdom of adopting the multiple-unit system for handling suburban service. The New York Central has already reaped its reward in adopting this method in the elimination of practically all of the delays of train service at the Grand Central Station that heretofore largely resulted from the multiplicity of movements of steam locomotives in passing to and from the engine-house facilities and in switching from the head to the rear end of trains; in fact, apart from other improvements made at this terminal, the use of the multiple-unit system has at this time resulted in an increase in the capacity of the station of at least 33 per cent. Moreover, the rapid acceleration of this character of equipment as compared with locomotive practice has resulted in the ability of the Operating Department to maintain schedules with a reduced rate of speed between stations.

While on this subject of acceleration it might be well to add that in making a selection between the rival electric systems, relative acceleration should be compared not only in connection with the movement of suburban trains, but also through trains hauled by electric locomotives. Some recent observations have demonstrated to the speaker the marked difference of acceleration between the two principal electric systems. In changing motive power from steam to electricity on trunk line railroads this question of acceleration is one of the greatest attractions and therefore should not be lost sight of in determining upon any electric system which may offer no greater advantages in that regard than the steam locomotive that it displaces.

Another point mentioned by Mr. Sprague that seemed worthy of special notice was bonding of track rails. The New York Central has realized the wisdom of its course in adopting bonds concealed beneath the fish plates, as there has been no loss from their theft, whereas on other roads where this precaution has not been taken, electrical operation has been seriously interfered with from the theft of exposed bonds.

To do their part in popularizing with steam railroad men the use of electricity in solving trunk line problems, the speaker suggested that all inventive genius of the great manufacturing corporations in this country should be bent on devising means of accomplishing a desired result at less cost, as this will mean in the end such an increase in the use of electricity as a motive power as to more than compensate for the comparatively small loss in decreased unit prices of apparatus. One of the promising movements in this direction is the hints that have been given of the possibility of substituting for the expensive rotary converters and substation attendance with the direct-current system, a very simple device which will cost very little and require no attendance. This one feature, if successful, will go far toward strengthening the hand of the steam railroad enthusiast in extending the use of electricity more generally than now seems possible.

The signal field is also one in which there is room for improvement in reducing costs of installation so as to make the use of electricity feasible from a financial standpoint. The use of electricity at the present day requires the throwing away of old-type signal and interlocking systems and the installation of an entirely new system at a vast cost, due to the necessity for use of the track rails for return propulsion current. On one of the branch lines of the New York Central the substitution of electricity for steam has been indefinitely postponed because of the attendant great cost of making a change in the block signals and interlocking; but one of the electrical companies now gives ground for hope that a new method has been devised which will do away with the necessity for the more expensive portions of the apparatus and so far reduce the cost of the change of signaling as to make feasible the electrification of the branch road.

As to the relative merits of overhead and third rail working conductors, steam railroad men have been more or less alarmed at the freedom with which contending enthusiasts argue as to the danger attendant upon the selection of either. It must be conceded that in return for the many advantages that come with the use of electricity, there are certain disadvantages, among which is the added danger from the use of working conductors, whether third rail or overhead. The question simply simmers down to the selection of the system which appears to offer the least danger. Mr. Sprague has exhaustively covered the merits and demerits of each, and it remains for the steam railroad men to make a selection, having in mind the desiderata of noninterference with the view of signals, elasticity in the adjustment of tracks to new grades and alignment and the laying of additional tracks, minimum danger from derailments, safety to employees and economy of maintenance.

Regarding the question of standardization, L. B. Stillwell said that in his paper, read at the January meeting, nothing was said which excluded from further consideration the three-phase alternating-current system or any other alternating-current system; neither was the use of direct-current motors opposed, at any voltage in any kind of service, except trunk-line service, in which it is proposed to substitute the electric motor for the steam locomotive. The line which divides trunk-line service from interurban service, of the class to which hitherto electricity has been applied, is sufficiently distinct, in most cases, to be recognized without difficulty. For interurban service the speaker had used, and may continue to use for some time to come, direct-current equipment. Every real improvement in electric equipment adapted to rolling stock, whether that equipment be of the direct-current type or the alternating-current type, has its value. Each specific case of proposed installation obviously calls for careful comparison of available and adequate systems. Such comparisons, however, if they are to lead to conclusions that shall stand the test of time, must take into account not only existing and available equipment, but must recognize also tendencies in the development of the art and consider probabilities of future extensions and possible connections of the specific line under consideration.

For trunk line operation the speaker had held and still holds the opinion that the 15-cycle alternating current single-phase system possesses inherent characteristics which, in this class of work, constitute controlling advantages as compared with any direct-current system that has been suggested, or is liable to be developed into an operative system. With this opinion, Mr. Sprague's paper joined issue. In the oral discussion of the paper of January 25th, Mr. Sprague stated his position with emphasis by saying, "I am going to make a prophecy—that on a large number of lines which can by any stretch of imagination be considered as subject to a reasonable prospect of electrification, that 1200 or 1500 volts will, on any present development known, give better results in every way than the alternating-current 15 or 25-cycle overhead system." . . .

The present paper, while presenting certain data and opinions purporting to sustain the contention that the 1200-volt direct-current system is superior to the 15-cycle alternating-current system, presents no sufficient and fairly comparable data upon which any such conclusions can be based. The only data which it presents in a comparison of the relative outputs, speeds and weights of the contrasted types of motor are those in which a direct-current motor rated at 240 horse-power and an alternating-current, 25-cycle motor rated at 125 horse-power, are compared. No conclusions as broad and far reaching as that which this paper apparently endeavors to establish can be based upon a single comparison of this kind. It is defective for the following reasons:

(1) It compares two motors of equal weight. This comparison used as a basis for a general conclusion obviously is unfair to the alternating-current motor, as it takes advantage of the fact that increase in the size of motors of any type, alternating-current or direct-current, implies reduction in weight per horse-power. Had the comparison brought together two motors of equal type the ratio of weights would have been far less than is the ratio of output when equal weights are considered. This particular case of a motor-car equipment in which it appears that four alternating-current motors would be required to do the work of two direct-current motors is one which had come up in the speaker's experience, but obviously it is no proof that similar relations would hold, for example, in equipping a locomotive with a given aggregate horse-power.

(2) The comparison is made with a 550-volt direct-current motor weighing, without gear, gear case and pinion, only twenty-three pounds per horse-power (one-hour rating). This is extraordinarily light and indicates that the motor is, in respect to the relation of weight to output, superior to anything in general use. The latest 200-horse-power motors offered within the last sixty days to the Interborough Company by our leading manufacturers weigh, respectively, twenty-eight and thirty pounds per horse-power (one-hour rating). The alternating-current motor, on the other hand, is characterized by a higher relation of weight to output than other single-phase motors of comparable output in the market.

(3) The comparison is between a direct-current and an alternating-current motor operating at 25 cycles, not 15 cycles, which is the frequency suggested by Mr. Putnam and the speaker. The 25-cycle motor has a far higher ratio of weight to output than 15-cycle motor of the same output.

The paper emphasizes the statement that "Capacity is the keynote of equipment." With this conclusion few will differ. In our consideration of capacity of equipment, however, we should not limit our attention to the motor, but should take into consideration also the comparative methods of transmitting power to the moving trains. In general, the choice of a system will depend upon the ratio of capacity as measured in tractive effort to aggregate cost of equipment. The converter substations are, as is well recognized, a very expensive element of the d. c. system, as it would be applied to anything resembling a trunk line—expensive not only in first cost, but relatively still more so in annual cost and in complication of the distributing system. There are to-day in operation in New York City something over eighty 1500 k. w. converter units for the purchase and installation of which the speaker had accepted responsibility. While this machinery is doing excellent service he knew enough of its cost and limitations to realize that for trunk line railroad operation in the broad sense a system which employs the converter as an essential link between the coal pile and the train must give way to a system which eliminates this link, provided the single-phase alternating-current motor is designed and manufactured with anything approximating the care which to-day is bestowed upon the direct-current motor.

With reference to a specific installation which he was studying, the speaker said that he recently obtained from the engineers of one of the leading manufacturing companies comparative figures relating to 15-cycle single-phase alternating-current motors of 200 horse-power at 1-hour rating and 600 volts direct-current motors of the same output. These motors are practically identical in speed when delivering 200-horse-power. The data in which he was particularly interested were the maximum vertical dimensions and the weights of these motors. The maximum vertical dimensions of the alternating-current motor is 36½", that of the direct-current motor 1⅝" less. The weight of the alternating-current motor is 6280 pounds; that of the direct-current motor 6000 pounds, both of these weights are exclusive of gear, gear case and pinion. The alternating-current motor requires a wheel base one foot longer than is necessary with the direct-current motor. The ratings in the case of both motors are based upon the same rise of temperature without forced ventilation.

The speaker was not sure that he understood the author's reference to the implied necessity of increasing the current carrying capacity of steel conductors. He quotes from the report of the Commission of the recent International Electrical Congress to show that on 80-pound rails the ratio of impedance to resistance at 25-cycles is about nine to one. This difference, of course, is well known, but in transmitting a given amount of power by single-phase alternating-current through overhead trolley and track return at 11,000 volts, even when a frequency as high as 25-cycles is employed, the reduction in current employed in current employed by the increased voltage makes the total drop in the circuit as measured in percentage of applied potential less than $^1/_{40}$ the drop of a direct-current system operating through the same circuit at 1200 volts.

It should be noted carefully that while the only comparative data given with respect to motor performance relate to the 550-volt direct-current motor, the paper implies that in competition with the alternating-current system a direct-current potential of 1200 volts will be used. It is for our designing engineers to supply adequate data, but the speaker was of the opinion that comparing the 15-cycle single-phase alternating-current motor with the 1200-volt direct-current motor, the latter in general will have very little if any advantage in respect to dimensions or weight. Moreover, it is not to be lightly assumed that rotary converters delivering 1200 volts would be found as cheap and reliable as the 600-volt machines now in use.

When we come to consider the auxiliary car equipment and wiring there is a very radical difference in favor of the alternating-current system. In this field, as in the lighting field, the transformer is the key to the solution of the general problem of transmitting energy at reasonable cost and utilizing it at safe and easily controlled potentials.

The next speaker, W. B. Potter, of the General Electric Company, said it was not their intention to be the advocates of any particular system for the sake of the system itself. In nearly every case there are controlling conditions which in themselves are a sufficient argument to determine which particular method of operation is the best suited to those conditions.

With respect to one of the installations that had been spoken of in connection with a trunk line railroad, there existed conditions which made it obligatory to operate for a considerable portion of the distance with direct-current. It did not appear to him, with the state of the art as it then existed, or is at the present time, that the particular installation which had been referred to was a place to try out and develop the single-phase alternating-current. He thought Mr. Wilgus expressed it well when he said that the place of experiments of that kind was on the interurban or suburban roads, where the conditions would naturally be better suited, and where failure, or only partial success, or any difficulties that might be met with, would be less serious in their results with reference to the traveling public.

The same held true in a large measure with one of the other large single-phase installations that had been spoken of. There the distance was a matter of only a few miles, and direct-current for the conditions as they existed, not because of any desire to advocate direct-current, as in the case of the tunnel which Mr. Wilgus spoke of, appeared to be, and in his opinion was, a cheaper and more reliable system for such a purpose.

For a number of years the direct-current motor was made principally with respect to its mechanical features. Within the past year or so there has been made a distinct and radical improvement with respect to its commutation, and direct-current motors having commutating poles will undoubtedly be the type of direct-current motor to be used in the future. In fact, a number of thousand of such motors are already being manufactured on orders received and many others are in contemplation. One of the particular difficulties with a single phase motor has been commutation—that has been the feature which has limited its capacity, which has decreased its reliability. Also by reason of the difficulties with commutation, the armature speed has been considerably higher. All of these features have tended to make the motor less desirable as a motor than the direct-current motor.

The speaker said that he believed without doubt (for he had sufficient evidence to warrant him making the statement) that a single-phase motor can be produced in which the commutation is good if not better than the direct-current motors without commutating poles, in which the armature speed will not be more than 15 per cent. higher, with a larger air gap than has been used here before, and with conditions for general operation that will make that motor much more nearly comparable to the direct-current motor than anything thus far, and this without the introduction of any extraneous resistance and with an increase in efficiency of several per cent.

The weights of this motor will still be in the neighborhood of 25 per cent. more than the direct-current motor of the same horse-power rated on the hourly basis. This does not mean by any means that the alternating-current motor takes precedence, but it means that the alternating-current motor has been improved and improvements will continue to be made so that any conclusions which may be drawn with respect to the proper field of direct-current or alternating-current motors must not only take into account the conditions to be met, but also the improvements that will take place in the art, and with respect not only to alternating-current, but direct-current as well.

Speaking on the question of high-voltage direct-current, the speaker said that at the present time 600 volts direct-current are well recognized as the standard, and he would suggest that in the consideration of higher voltage direct-current, which unquestionably will be used—in fact, there are a number of such installations being put in at the present time—that the next step be 1200 volts. To reach the 1200 volts by successive stages will induce an interminable complication with respect to the operating company, because, so far as the manufacturing company is concerned, it is simply a question of development, but it is something which is expensive and must be paid for, and it will simplify the development of direct-current very much to go from 600 volts to 1200 volts, and not spread along through 700 volts, 800 volts, 1000 volts, etc., which might be the natural disposition in increasing the direct-current potential.

With respect to the several rival systems, so-called, Mr. Potter called attention to his connection with these several systems to this extent—that at the present time they were building 600 and 1200 volts direct-current, 6000 volts 3-phase, and a number of 25-cycle single-phase installations.

Speaking on the comparison between direct-current and single-phase alternating-current apparatus, Mr. Chas. F. Scott said that he had been somewhat interested to detect the method of the author in arriving at conclusions which are so largely at variance with those of some other engineers.

First of all, he lays stress upon the relative capacity of the motors of the two types as being one of the important and controlling elements in reaching a decision. He takes certain data and a certain basis of comparison, and from these reaches apparently logical conclusions. The question then arises, Is that data correct; is the basis of comparison correct? If not, is there not other data and other bases of comparison from which conclusions may be drawn by the same method, but perhaps with different results. Mr. Stillwell had touched upon this, and Mr. Storer would later take up specifically points of comparison between the operations of the two types of motors, discussing in particular the points made by Mr. Sprague and arriving at conclusions by somewhat the same methods, but with somewhat different results.

It had seemed to the speaker, further, that a number of points which Mr. Sprague had taken up had been comparisons on a particular basis, and that he had not considered fully the different methods or conditions under which the two motors may operate. For example, he had shown the curves of the two motors; he had shown that the alternating-current motor had at light load a much higher speed than the direct-current motor under the conditions taken. There is an apparent conclusion, therefore, that the alternating-current motor is lacking in the excellent characteristics possessed by the direct-current motor.

It seemed to the speaker that the author had failed there to call attention to another point, that is, the ready adjustability of voltage in the alternating-current system by means of voltage taps from the transformer. By this means the motor, instead of carrying through its full curve with a constantly applied voltage, which is the usual condition with the direct-current motor, may have different voltages applied. It may, therefore, develop its different torques at different speeds, depending on the controller position. Under the control, therefore, of the motorman, the alternating-current motor may have different characteristics of acceleration; it may accelerate to a high point; it may have the same mean acceleration from start to maximum speed, with a less maximum rate of acceleration.

Another point in which changed conditions were not taken into consideration is that of rail loss; although the loss per ampere may be greater, the loss per kilowatt may, as pointed out by Mr. Stillwell, be much less.

It seemed to the speaker that in the treatment of the subject the author had, possibly unconsciously, assumed the direct-current motor and its characteristics as the ideal, and that wherever the other motor had different characteristics, these characteristics were naturally and *per se* objectionable. At any rate, it had seemed to the speaker that the author had not recognized or emphasized certain advantages on the side of the alternating motor, where these advantages occur.

In certain cases the voltage control can give a higher speed to a motor in service than its normal. The application of higher voltage gives not only higher speed, but higher output to the motor. Something in the same nature is attained by field control in the direct-current motor, but the field control is a method of adjusting speed without changing the capacity of the motor. The voltage applied to a motor and the current through the motor may remain the same, and hence its capacity. But with the alternating motor an increasing voltage applied to the motor allows an increased output from the motor, with the same current going through its armature.

The paper also gives little, or very small consideration to the advantages which come from the alternating system between the power house and the train, through the elimination of the rotary converters and the reduced current to be carried. Mr. Stillwell had already referred to this. The matter of rheostatic losses in the direct-current equipment, a matter which in some kinds of service is of considerable importance, had not been touched upon.

The matter of braking had been referred to. It will be of interest to know in this connection that a paper had been prepared for the annual convention of the Institute dealing with braking by the single-phase motors. In this system, which had been worked out and fully tested, it was found that the single-phase motor lends itself admirably to braking, covering all the desirable qualities in braking which have been called for in the paper, and doing far more than has been shown possible with the direct-current motor, or any other motor. This paper shows that the single-phase motor surpasses its rivals in this respect in a way which will probably be admitted by all.

Regarding the statements relating to single-phase equipments, N. W. Storer said that he desired to take issue with the author of the paper, as information which he had, based on the present practice of the Westinghouse Electric & Manufacturing Company, was entirely inconsistent with what appears in the paper. In the first place, there are given fifteen so-called differences between direct-current and the alternating-current single-phase motors. Although many of these are of little consequence, they will nevertheless be considered in order.

The direct-current motor has a solid frame like the single-phase motor. It has, further, two or more laminated poles bolted in, and, if the interpole construction is used, has as many more relatively small and delicate poles. The alternating-current motor as built by the Westinghouse Electric & Manufacturing Company has, in all sizes up to a diameter of 38″, field punchings made in a single piece and built up and keyed in the frame, making it as solid a construction as an armature on its spider. A claim for less rigidity in the single-phase motor is hardly sustained.

"One has exposed and hence freely ventilated field coils, the other has field coils embedded in the field magnets." It is known to most motor designers that coils in contact with iron will dissipate heat much faster than when in the open air. This is especially true of coils in an enclosed motor. The speaker had repeatedly noticed that motor field coils which have been removed on account of roasting out have shown the insulation in contact with the pole pieces to be in good condition, while other sides were badly roasted. He therefore knew that in respect to ventilation of field coils the single-phase motor is superior to the direct-current motor. Smaller cross section of coils also allows the heat to be radiated better with the single-phase motors, and the fact that a large part of the loss in the motor is concentrated in the field iron will enable the motor to dissipate a much larger amount of heat for a given temperature rise than a direct-current motor.

Concerning "Polar Clearance." Many thousands of direct-current motors are to-day in operation with a clearance of 1/8″ to 3/16″ between poles and armatures, and in practically all cases where more than 3/16″ clearance is used it is for electrical reasons. Further, while the smaller air gap used for single-phase motors was at first much feared, the fears have proved to be without foundation, and the present clearances of from .1″ to .15″ have proved to be ample and fully as good as .15″ to .25″ on direct-current motors because there is no unbalanced magnetic pull.

Concerning "Torque." The torque of an armature is the pull it will exert at one-foot radius. It therefore makes no difference in the result whether it is obtained with large flux and few armature conductors, or *vice versa*.

"Much Larger Diameter of Armature and Commutator and Much Higher Speed." A very general statement. What are the facts?

The armature diameters ordinarily run from 5 to 15 per cent. larger than for direct-current motors of corresponding output. It is undoubtedly true that the armature speeds of the earlier single-phase motors were much higher than the speeds of corresponding direct-current motors. At the present time, however, the speed at the nominal rating of the motor is practically the same as that of direct-current motors and the maximum operating armature speeds are within the safe limits set for direct-current motors.

Concerning "gear reduction and gear pitch." The gear reduction, of course, depends upon the speed, and as far as gear pitch is concerned, the same gear pitch is used for single-phase motors as for direct-current motors of the same capacity.

"Windings of one subject to electrical strains of one character; those of the other subjects to strains of rapidly variable and alternating character." No conclusion is drawn from this. It may be of interest to know that there have been a number of instances where the single-phase motor had broken down in service on a direct-current section of the line, necessitating cutting it out of the circuit; but when the car reached the alternating-current section of the line it had been again connected in circuit and operated satisfactorily, thus indicating that the electrical strains on alternating-current are less severe than with direct-current.

Concerning the "variable torque of the single-phase motor." No comment is made as to the relative merits of uniform or pulsating torque. In a recent discussion before the Institute, Mr. Potter called attention to certain characteristics of the torque exerted by an alternating motor, especially when it reached the slipping point of the wheels. It was stated that there was an apparent advantage in the pulsating torque, because when the motor starts to slip it does not immediately decrease its mean torque as is done in the case of the direct-current motor, but slips in a series of jerks apparently regaining the hold on the rail at every pulsation.

Concerning the "number of poles." The paper states that the direct-current motor has "two or four main poles only." No direct-current motors built in the last fifteen years, except those on the New York Central locomotives, have less than four poles. The paper states that the alternating-current motor has "eight to fourteen poles." The single-phase motors built by the Westinghouse Electric & Manufacturing Company have four poles for all sizes up to and including 125 horse-power. The largest single-phase motor thus far built has a capacity of 500 horse-power. It has but twelve poles.

Concerning "a high torque while standing still." Railway motors are designed to move a train rather than hold it at rest. At the same time, the single-phase motor is amply protected against mistakes of motormen in leaving the current on the motor for a half-minute or so with brakes set.

Concerning "resistance in commutator leads." It is well known that the resistance leads which are used in single-phase armatures are used for the purpose of reducing the loss due to the transformer action in the short-circuited coil to a minimum. Their presence is fully justified and the efficiency is higher than it would be if they were not used.

More or less had been said in the paper concerning the lower efficiency of the single-phase motor and inference might be drawn that it is about 10 per cent. lower than that of the corresponding direct-current motor. To show what modern motors are capable of doing, the speaker gave the efficiencies of corresponding sizes of direct-current and alternating-current motors at different percentages of their full load torque.

Per Cent. of Full Load Torque	D. C. 90 H.-P. Motor	A. C. 25 Cycle 100 H.-P. Motor	D. C. 200 H.-P. Motor	A. C. 15-Cycle 200 H.-P. Motor
125	86.25	82	88.8	87.3
100	86.8	85	89	88
80	87	86	89.2	88.3
60	86.5	86.8	88.8	87.7
40	85	86	87	85
25	82	82.5	84	82

From this it does not appear that within the ordinary range of tractive efforts exerted by railway motors the single-phase motor is so far deficient. In fact, it comes remarkably close to that of the direct-current motor.

Concerning the comparison between the 125 horse-power and the so-called 240-horse-power motor contained in the paper, the speaker took issue as to its fairness. In his opinion, the only fair way to compare the performance of single-phase motors with that of direct-current motors was to assume a car with a certain seating capacity, and then consider what equipments, alternating-current and direct-current, are suitable for this service. It was not fair to assume a car of a certain total weight, carrying in one case fewer passengers than the other. The object of a railway company is to accommodate a given traffic. It follows, therefore, that an equipment should be provided which will render the service. Motors should be selected on the basis of their speed-time curves and in accordance with their particular characteristics, rather than upon the simple horse-power basis.

Further, it was unfair to take an isolated case of a single-phase motor which may be heavier than the ordinary, and compare it with a direct-current motor which is certainly much lighter than ordinary motors of that capacity. If the author of the paper, in seeking to compare the two types of motors, had taken the 25-cycle 75-horse-power single-phase motor referred to later on in the paper, his conclusions might have been quite different. The weight which he assigns is 4199 pounds. The weight of corresponding direct-current motors is 3500 to 4200 pounds.

Moreover, if the single-phase motor to which he referred were operated on 15 cycles instead of 25, its output would be 90 to 95 horse-power, which would lead to conclusions quite at variance with others in the paper. The weight of a quadruple equipment of 90 horse-power direct-current motors furnished by the Westinghouse Electric & Manufacturing Company would be approximately 20,000 pounds. The corresponding weight of a quadruple equipment of 90 horse-power, 15-cycle motors, with oil-insulated transformers equipped for 11,000 volts, would be approximately 27,500 pounds, an increase of about 37.5 per cent. This extra weight added to a 40-ton car would amount to about 10 per cent. and owing to the greater efficiency in the control of the single-phase motors, the power consumption of the car, including transformers, would in most classes of service be approximately the same as that of the direct-current motor at the trolley and would be much less at the power house. A car for passenger service can be equipped with two 200-horse-power, 15-cycle single-phase motors giving ample clearance on 37-inch wheels. These two motors will operate a car with the same power consumption per car-mile at the car on runs as long as five or six miles, as would be obtained with a car of the same capacity operated with an equipment of 200-horse-power direct-current motors. On shorter runs the relative power consumption would be less.

Concerning the use of high-voltage direct-current, the speaker said that motors can certainly be built to commutate satisfactorily on 1200 volts direct-current. Such motors, however, must restrict the voltage between bars to a safe limit and have extra space for insulation. The construction of this motor would therefore put it on a par with the 15-cycle single-phase motor both in weight and dimensions. Moreover, it would have practically the same air gap in moderate sizes of motors and might possibly have to be designated with the same style of compensating winding on the field as is now used for single-phase motors. It would have, in addition, the disadvantage of a high voltage always present on the windings and brush holders.

If it were not for the greater possibilities of the single-phase system, there is no question but that the high-voltage direct-current motor would be quite attractive. As it is, systems should be developed which offer the best solution for the entire railway problem. To attempt to develop a number of systems would result in not only scattering the energies of manufacturing companies, but retard the ultimate solution and supply the railways with a heterogeneous collection of equipments that would postpone standardization for many years.

William McClellan said he had studied various types of motors, comparing alternating with the direct-current type for certain service, and the conclusions reached agreed more closely with the statements made by those who had discussed the question rather than with the statements made by the author. He had also stood on an 11,000-volt train and operated it, and found it extremely flexible in every way, in fact, there was nothing to tell that it was any different from an ordinary trolley-car or multiple unit train. In fact, the acceleration was smoother, which is one of the advantages claimed for it.

He had taken the covers off the commutators, and the commutation was absolutely perfect, there being no sparks whatever, in spite of the fact that the car at the time was pulling a heavy overload and was acting as a locomotive, so that no complaints could be raised on that score.

A. H. Armstrong said that his very recent impressions of the alternating-motor, which had been gradually growing, had been somewhat broken up. He had witnessed a test of an alternating-current motor, rated nominally at 125-horse-power, which operated at 50 per cent. overload with perfectly black commutation, hardly a sign of a spark, and the machine carried only half its usual complement of brushes.

It is true that the direct-current motor is also open to certain developments. Two years ago we would hardly make the statement that 1200 volts was a feasible, common-sense method of construction. The commutating-pole motor has been developed and largely applied to the railway design, and the 1200-volt motor is a perfect success, and we can go higher if necessity calls for it. The alternating-current motor is also developing, and it is very hard to say just where it will stop.

Mr. Armstrong was of the opinion that there is no use in going down to 15 cycles with all the incidental complication involved in so doing. He had heard the statement expressed to the effect that in and around the large cities the total electrical power development was represented in the railway field by about 25 per cent., that is, if all the electric railroads in and around the cities were operated, only 25 per cent. of the total power generated would be required for that purpose, the other 75 per cent. to be used for lighting, small power work and an incidental supply.

All of the large cities have adopted and installed 25 cycles as a nucleus, and it would be folly to think of anything else coming in. The plants are already represented by thousands of k. w's., and this question of standardization is one in which much broader factors enter than the possible design of a railway motor. Then, too, a series-wound alternating-current motor, as known to-day, is subject to change. There may not be the same necessity, apparently, to go to 15 cycles that there is to-day.

Dr. Steinmetz said there is quite a class of service where alternating motors are necessary. If we consider a long railway with very infrequent, irregular service, with a considerable amount of freight traffic which is very fluctuating in nature, in short, conditions where rotary converter substations would show a very poor load factor, in such cases direct-current appears out of the question. Here is the field for the alternating-current motor or steam locomotive.

Again, in other cases, where we have a four-track or a six-track railway with such heavy traffic that the distance between trains is limited only by the safe headway—or a little shorter, sometimes—in such a case the load factor in the converter substation will be so high and steady, the rapidity of acceleration required so considerable, and the maximum capacity of the motor so great, that the advantage is decidedly in favor of the direct-current, and there should be in such case no excuse for using alternating-current motors.

The speaker did not share the objection to the rotary converter, and did not believe there is so great a gain in eliminating this link. It is an advantage in a system to eliminate some of the links in the chain, but what we want to eliminate is the weakest link, and that is not the rotary converter, but the motor. The rotary converter is about the strongest link in the chain.

However, between these two extremes there is a very wide field, where either the alternating-current or the direct-current motor may be used, or rather where different engineers may be justified, impartially in arriving at different conclusions: but what we should guard against is not to adopt any one system which precludes us forever from going to the other, nor to adopt any specialty that means going to an odd frequency. In regard to the 1200 volt direct-current motor, Dr. Steinmetz concluded that its commutation is so infinitely superior to the commutation of any alternating-current motor he had ever seen, except in the last week, that there was no comparison. As Mr. Armstrong had said alternating-current motors could be operated on heavy overloads, absolutely sparkless, which were just as good as the standard direct-current motor, or probably a little better.

The Induction Motor

Part II.

By C. J. SPENCER

THE resistance of the primary winding is found by multiplying the length in feet of one turn by the number of turns per leg and multiplying this result by the resistance per foot. Where it is found desirable to wind the primary with

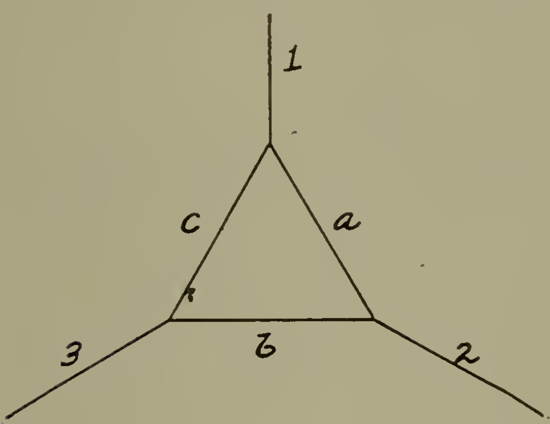


FIG. 1.

copper strap, that is, wire of rectangular section, the method found simplest is to express the sectional area in circular mils and calculate the resistance by comparing the area found with a wire of approximately the same area. Otherwise there is some difficulty in finding the proper decimal point, owing to the small resistance per foot.

A rectangular section of copper wire five-tenths by two-tenths inches has an area of one-tenth square inches. We know there are a million circular mils in a circle of one inch diameter and that a square inch contains one million square mils. The area of the circle is .7854 times that of a square having one side equal to the circle diameter, consequently there are 785,400 square mils in the circle of one inch diameter. The copper strap .5 x .2 inches =.1 sq. in. has an area of 127,300 circular mils and is a little less than No. 00 B & S gauge wire. The wire table in one of the handbooks gives the resistance per foot of No. 00 B & S wire as .0000778 ohms at 20°C., .00008692 ohms at 50°C. and .00009633 ohms at 80°C. The resistance at 80°C. is almost 25 per cent. greater than at 20°C., which is about the average temperature of the air and the resistance given for the lowest temperature is the figure usually given in wire tables. What we usually want to know is the performance of the motor operating at full load when the windings are hot; resistances at normal temperatures are comparatively unimportant. With a rise of temperature of 40°C. and a room temperature of 25°C., the operating temperature is 65°C. The resistance of No. 00 B & S wire at 65°C. is one-half the sum of the resistances at 50° and 80°, or .000091625 ohms per foot. The area of the copper strap is less than the area of No. 00 B & S, consequently its resistance will be greater and directly in proportion to the relative areas.

$$000091625 \times \frac{133100}{127300} = 000096 \text{ per ft.}$$

Copper wire can be obtained on the market that will equal in conductivity the figures given in wire tables for pure copper.

A six-pole motor with four slots per pole per phase and four conductors per slot has 96 half turns or 48 complete turns per leg. Assume the mean length per turn as three feet, then the resistance per leg is

$$3 \text{ ft.} \times 48 \text{ turns} \times .000096 \text{ ohms per ft.} = .013824 \text{ ohms.}$$

The resistance per phase depends on whether the motor be star connected or delta connected. If delta connected, the resistance per leg equals the resistance per phase. If star connected, the resistance per phase is twice the resistance per leg, where the resistance per phase is measured between any two of the motor terminals.

The current per leg is equal to the current in one line wire with the star connection of primary winding. The current in each line wire divides in the delta-connected primary, a portion flowing through each leg to which the line wire is connected. The relative amounts of current in motor and line are represented graphically by Fig. 1, in which the three phases of the line are numbered *1*, *2* and *3*, and the three legs of the delta-connected primary winding are lettered *a*, *b* and *c*.

The relation between the value of current in any part of the system to that in any other part is the same as the relation between the length of the line representing the first part and its projection on the other part. The current in line wire No. 1 flows through legs *a* and *c*. The value of current in line wire *1* is to the sum of the projections of *a* and *c* on *1* produced as the value of current in *a* is to the length of *a*. The sum of the projections of *a* and *c* on *1* is 1.732 times the length of a, then the current in *1* is 1.732 times the current in *a*. Connecting the primary in star gives .013824 volts drop per ampere per leg, which, by reference to Fig. 2, is found to amount to .024 volts drop per phase. With the delta connection and one ampere in the line, the current per leg is .58 ampere and the volts drop per leg is .008 volts; this is also the drop per phase. The delta connection gives one-third the drop in voltage of the same winding connected in star.

It will be shown that the magnetizing current is greater with the delta connection than with the star connection of the primary, the number of turns remaining the same for both connections. The choice of primary connections is determined by the voltage and frequency of the line and the motor capacity. Very large motors operating on low voltages at high frequencies require windings of such

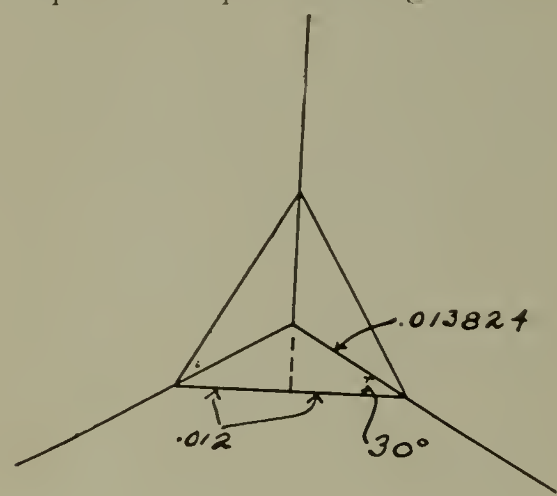


FIG. 2.

large area that the skin effect shows an appreciable loss, or the large flat strap cannot be bent to the shape desired, making a smaller wire desirable. Large motors for low voltages may be wound with two wires connected in parallel or a single wire delta connected.

The reactance of the primary winding is found in the same way as already shown for finding the reactance of the secondary and this calculation is given here only to show the effect of different slot shapes. In general, slots may be deep and narrow, or wide and shallow, they may be closed,

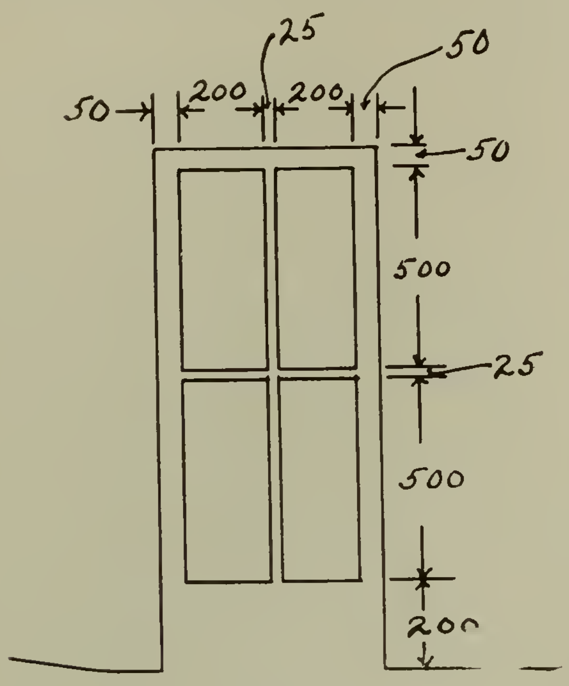


FIG. 3.

partially closed or open. The least reactance is obtained for any given number and size of conductors with a wide shallow open slot. To obtain a wide and shallow slot the motor diameter must be large. The open slot presents but a small amount of iron at the air gap, thus making the magnetizing current large. The deep narrow slot admits of a small motor at the expense of the primary reactance. The partially closed slot is difficult to wind and repair, but has the desirable feature of a large amount of iron at the air gap, with consequent reduction of magnetizing current.

To illustrate the relative reactances of a narrow deep slot and a wide shallow slot, we will find the reactances of two open slots, either of which will take four conductors five-tenths by two-tenths inches. Allow twenty-five mils between conductors and fifty mils between conductors and iron for insulation and clearance. The slot may be made as per Fig. 3. Assume an air gap of one-thirty-second inch and a length of iron of five inches.

The leakage flux between copper and the center line of the air gap is through an area of 5 by .216 inches and the length of path is .525 inches. The c. g. s. lines per ampere per conductor amount to

$$\frac{4\pi \times 4 \text{ turns} \times 1 \text{ amp.}}{10} = B \frac{1.33 \text{ cm.}}{6.97 \text{ sq. cm.}}$$

$$B = 26.25$$

The back e. m. f. induced per ampere per leg at 60 cycles is

back e. m. f. $= 10^{-8}\, 2\pi\, 60 \times 26.25 \times 4$ conductors per slot x 4 slots per pole x 6 poles

$= .0095$ volts.

If the slot were partially closed, as shown by Fig. 4, the length of leakage path would be reduced to one-third of that of the open slot and this portion of the reactance would be three times as great as that of the open slot with the same winding. This increase of this portion of the reactance does not affect the total motor reactance to a very great extent, and is compensated by the reduction in magnetizing current obtained with the partially closed slot, since the amount of iron at the air gap is increased. A number of turns is selected, in designing a motor, that will give the magnetizing current required, and when given this requirement the turns for a partially closed slot are fewer than for an open slot, so that the reactance actually becomes less with a partially closed slot.

The difficulties encountered in winding a primary with partially closed slots do not always permit of its adoption. With the winding here given, the slot could be closed to 225 mils and one conductor slipped in at a time, but the open slot admits of winding the coil on a form and slipping the entire coil in place. The relative advantages of the open and partially closed slots depend on the relative importance of mechanical construction and electrical performance of the motor.

The entirely enclosed slot increases the inductance to an immense amount at moderate loads when the permeability of the iron is high and to a smaller amount at full load. Another fault of the entirely enclosed slot is the amount of heating of the iron over the slot.

Suppose the slot to be made as shown by Fig. 5, where the iron is very thin at the point *a* and increases in thickness to the slot sides. It must be remembered that the primary leakage flux is produced by the primary ampere turns where they are not opposed by the secondary demagnetizing turns, and the flux at *a* depends only on the permeability of the iron and the primary current. If the iron be thin at *a*, then the flux at this point will be sufficient to heat the iron excessively to the injury of the adjacent insulation. Improperly designed partially closed slots will cause this same result. In fact, it has been observed that very thin iron projections of partially closed slots are heated excessively, though the explanations given for this result were not what have been given here.

Refer again to Fig. 3 and compute the reactance due to the leakage flux from one side of the slot to the other and through the conductors, as follows:

The length of the leakage path is .525 in. = 1.33 cm.

The area at any point distant x from the back of the slot is 5 dx sq. in. = 12.7 dx sq. cm.

The number of conductors is $\frac{4x}{1.025}$ on the inch basis of measurement or $\frac{4x}{2.6}$ reduced to centimeters.

$$\frac{4\pi \frac{4x}{2.6}}{10} = dB \frac{1.33}{12.7\,dx}$$

$$dB = 18,4\ x\ dx.$$

This flux cuts $\frac{4x}{2.6}$ conductors per slot and the back e. m. f. per slot is

$$d\,(\text{Back e. m. f.}) = 10^{-8}\, 2\pi\, 60 \text{ cycles } \frac{4x}{2.6}\, dB$$

$$\text{Back e. m. f.} = .0000355\, (x^3)_0^{2.6}$$

$$= .000625 \text{ volts per slot.}$$

There are four slots per pole and six poles, giving .015 volts per leg.

This is almost twice the inductance due to leakage through the wedge at the slot opening.

The total inductance for this slot (Fig. 3) per ampere per leg at 60 cycles is .0245 volts, without allowing for the inductance of end connectors.

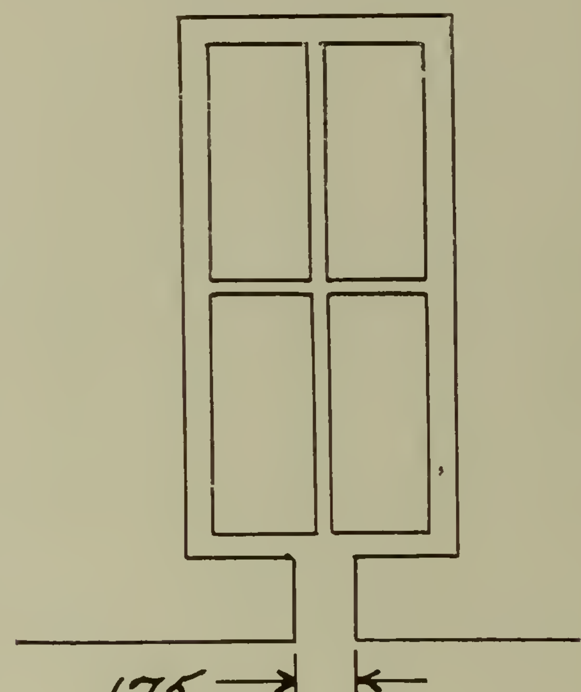


FIG. 4.

A calculation of the inductance of end turns is without value, so far as the result obtained is concerned, for, owing to the many assumptions necessary, the result will be extremely inaccurate. This calculation has some value, in that these connectors may be disposed to the best advantage for obtaining a minimum reactance and the calculation shows how to obtain a minimum reactance. It is a good general rule to make these connectors short and to place them close together. A good ventilation is also a desideratum to obtain, which the connectors should allow of air circulation between turns.

The same winding as shown by Fig. 3 can also be placed in a slot as shown by Fig. 6.

The inductance through the wedge is

$$\frac{4\,\pi \times 4}{10} = B\,\frac{2.86}{6.97}$$

B=12.2 c. g. s. lines
Back e. m. f.=.00442 volts

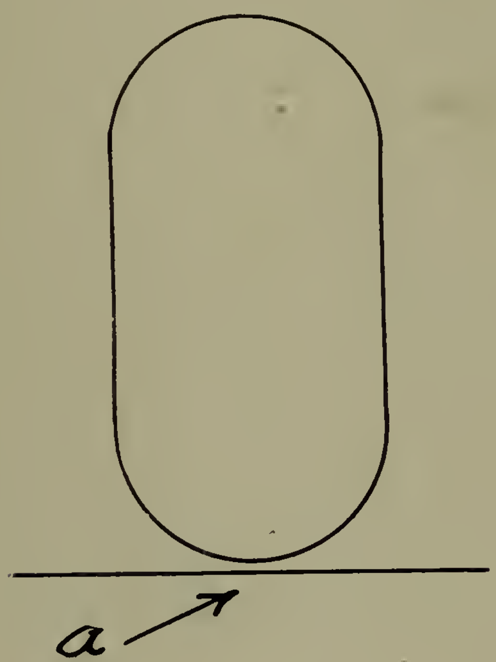


FIG. 5.

The inductance in the slot is

$$\frac{4\,\pi\,\frac{4\,x}{1.08}}{10} = d\,B\,\frac{2.86}{12.7\ dx}$$

$$d\,B = 20.7\ x\ dx$$

$$d\,(\text{Back e. m. f.}) = 10^{-8}\,2\,\pi\,60\,\frac{4\,x}{1.08}\,d\,B$$

$$\text{Back e. m. f.} = .0001\,(x\,)_{0}^{1.08}$$

$$= .000126 \text{ volts per slot.}$$

.000126 x 24 conductors=.003 volts per leg.

The inductance due to slot and wedge is .00742 volts per ampere or approximately one-third that of the slot shown by Fig. 3.

The wide slot can only be obtained by increasing the diameter of the motor. Induction motors are therefore made with as large a diameter as is permissible. The large diameter, however, results in a motor rotating part with large inertia. This is undesirable at starting, as the power required to bring the motor up to speed is large and the starting current is large. Since the potential energy of the rotating part is large, a brake made for a direct-current motor of any given capacity must be increased in size for an alternating-current motor of the same capacity. This fact is sometimes overlooked when installing brake equipments where the motor must be stopped quickly.

Knowing the primary and secondary resistance and reactance, there only remains to be found the magnetizing current and the demagnetizing effect of the secondary in order to find the complete motor performance. The effect of the magnetizing current on the motor performance at partial loads and at full load is greater than the effect of primary resistance and reactance and secondary reactance. The motor performance can be very closely approximated at partial loads by considering secondary resistance and the magnetizing turns of primary and secondary without taking into account the other items, but this method is not desirable, as the pull-out torque and starting current are of importance.

The starting current of the old types of induction motors is so large compared to that of modern motors that the effect on lighting circuits in reducing the line voltage at starting can be greatly reduced by installing motors of modern types. It is also desirable to obtain high-power factor at starting. The power factor and amount of current at starting depend on the reactance and resistance of primary and secondary windings, so that time and trouble expended in reducing the reactance of these windings is well repaid by the improved results obtained at starting.

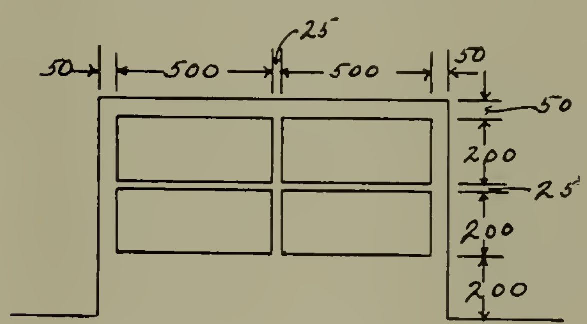


FIG. 6.

When the motor is running at synchronous speed without developing power for work or to overcome friction and windage, the impressed voltage is counteracted by the magnetic flux cutting the primary winding. The magnetizing current is that current which produces sufficient magnetic flux to generate a back e. m. f. that will equal the impressed voltage. This current is considered as not having an ohmic or inductive drop in voltage through the winding for the purpose of obtaining its value to be used in calculating the motor performance. The motor is considered as running under impossible conditions, that is, without consuming power and without drop in potential, due to resistance and reactance. A loss is incurred in the iron core of the motor from the magnetic reversal in the iron with alternating-current. There is no error in making the assumptions that the motor can be run without losses as the result to be obtained is for the purpose of calculation only. It must be remembered that the true magnetizing current cannot be directly measured on test. The difference between test results and the actual current for magnetization is, however, very slight.

Given a six-pole motor connected in star, let us find the flux necessary to induce an e. m. f. of 400 volts between phase terminals at sixty cycles per second. The volts per leg are:

$$\frac{400}{1.732} = 231 \text{ volts.}$$

This is the effective voltage. The maximum voltage is 327 volts. The maximum flux is found from the equation.

$$327 \text{ volts} = 10^{-8} \times 2\,\pi\,60 \times 48$$

complete turns per leg $\times$ B, where B represents the maximum active flux per pole in c. g. s. lines.

B=1,800,000 active c. g. s. lines per pole.

The magnetizing effect of the winding is represented by Fig. 7, where the conductors in the three phases are lettered *a*, *b* and *c*. The magneto motive force in the different teeth is plotted.

The magneto motive force is produced by the three phases. When the wave of magnetic flux and m. m. f. is in the position shown, the current in phase *a* is a maximum. When the current in any phase of a three-phase system is a maximum the current in the other two phases is at one-half its maximum. This is graphically shown by Fig. 8. Here the phases are shown as 60° apart, the m. m. f. of the successive poles being alternately positive and negative; the positive quadrants are taken as one positive pole and the negative quadrants as the next negative pole. The cosine of phase *a*

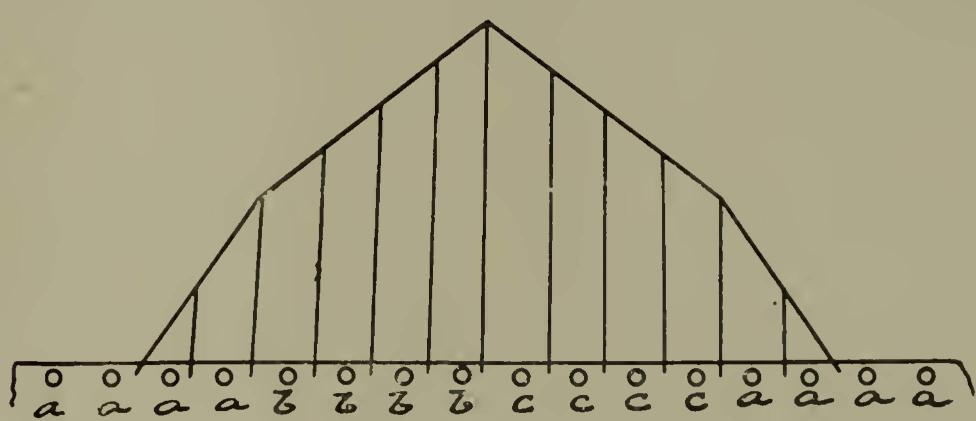


FIG. 7.

is unity and the cosines of phase b and c are each one-half . Phase a has its maximum current value and phases b and c are each one-half maximum. The m. m. f. of one-pole space and the

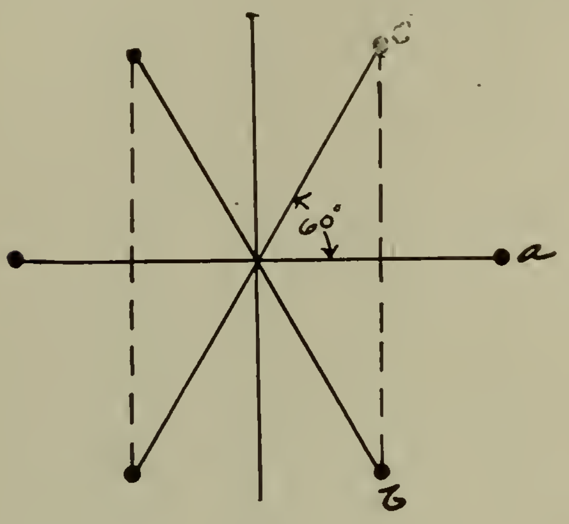


FIG. 8.

magnetic reluctance of this portion of the magnetic circuit only are considered. The other poles present exactly similar conditions.

There is no m. m. f. at the center of the group of slots a when the current in phase a is a maximum. At the next tooth to the central one four complete turns are producing the m. m. f.; at the second tooth there are eight turns; at the third tooth there are four more turns, each carrying one-half maximum current, or the equivalent of two turns with the same current as in phase a; and thus to the tooth of maximum m. m. f., where the ampere turns amount to sixteen per ampere for phase a. Since the m. m. f.'s vary as shown and the reluctance for all the teeth is the same when the reluctance of the path through air is taken as the entire reluctance of the circuit, the maximum flux through one tooth will be $\frac{16}{112}$ of the total.

Imagine the wave of flux to move to the left with respect to the conductors. One part of the wave is leaving the pole while part of the next wave is entering the pole in the opposite direction. At the instant represented by Fig. 7. there are a maximum number c. g. s. lines embraced by phase a and the voltage induced in this phase is zero.

As the wave moves with respect to the conductors, the part of the wave entering the pole and directly over the group of slots of the phase of maximum current and zero voltage neutralizes the part of the preceding wave which is directly over the same slots and leaving the pole. The distributed winding with four slots per pole per phase, as represented by Fig. 7, is not subjected to the total lines per pole, but only $\frac{104}{112}$ of the total wave is active.

We have found that 1,800,000 c. g. s. lines are required to counteract the 400 volts impressed on the motor terminals. The total c. g. s. lines per pole will be $\frac{112}{104}$ of 1,800,000=1,940,000 c. g. s. lines and the lines through the tooth of maximum induction are

$$\frac{16}{112} \text{ of } 1940000 = 277000$$

To find the bore diameter of primary iron, assume a maximum induction of 16,000 c. g. s. lines per square centimeter. Each tooth must have an area at the air gap of

$$\frac{277000}{16000} = 17.3 \text{ sq. cm.}$$

We have assumed a length of iron of five inches, or 12.7 cm., then the width of each tooth must be

$$\frac{17.3}{12.7} = 1.36 \text{ cm.}$$

The width of each tooth is 1.36 cm., or .54 inches. The slot shown in Fig. 3 has a width of .525 inches, giving a total width of slot and tooth of 1.065 inches. There are four slots per pole per phase, six poles and three phases, making a total of seventy-two slots and teeth for the motor. The required circumference is seventy-two times 1.065 inches or 77 inches and the bore 24.5 inches.

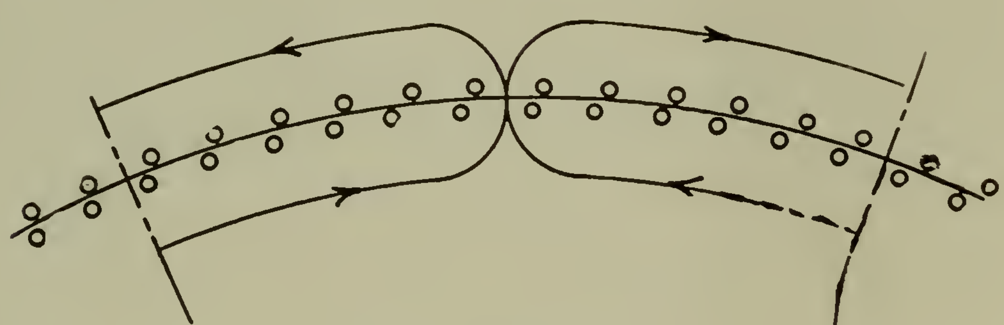


FIG. 9.

The magnetizing current will be that current which will give the required flux. Take an air gap of one-thirty-second inch measured on the radius that is between iron of primary and iron of secondary and neglect the reluctance of the iron. The length of path is in air $^1/_{32}$-inch. or .0795 cm. The area is 17.3 sq. cm., the flux is 277,000 c. g. s. lines and the number of magnetizing turns at the tooth of maximum induction are sixteen turns.

From this data we have

$$\frac{4 \pi 16 i}{10} = 277000 \frac{.0795}{17.3}$$

$$i = 63 \text{ amperes}$$

This is the maximum value of the current, the effective value is 44.5 amperes.

It is interesting to determine the magnetizing current for this motor when delta connected and on a 200-volt circuit. The maximum volts per leg are 283 volts and the active c. g. s. lines per pole.

$$\frac{283}{327} \times 1800000 = 1500000$$

The maximum flux per sq. cm. is

$$\frac{283}{327} \times 16000 = 13850$$

and the magnetizing current per leg is 54.5 amperes maximum, or 38.5 ampere effective. In this case the current per line wire is not equal to the current per leg, but is 1.732 times that current, or 67 amperes effective. If 400 volts be impressed on this winding and sufficient iron added to carry the magnetic flux, the magnetizing current would be twice that for 200 volts or 134 amperes. This is three times the current for the star connection having the same winding and the same air gap.

The reluctance of the iron in the magnetic circuit is appreciable with an air gap as small as $^1/_{32}$-inch. The flow of flux for one pole is represented by Fig. 9. Each pole winding takes care of the magnetic circuit for the pole, making it unnecessary to complete the magnetic circuits for all the poles. Considerable complication is involved, owing to the length of paths being different for different teeth. Where the reluctance of the air gap only was considered above, it was shown that the flux for all the teeth could be calculated by taking one tooth only and the tooth of maximum induction was selected in order to determine the maximum induction without making another calculation. The reluctance of the iron has the effect of diminishing the flux through the tooth of maximum induction to a greater extent than it diminishes the flux through the remaining teeth.

In order to find the increase in magnetizing current caused by the iron reluctance, the permeability of the iron must be known from previous tests. With the advance in elective and magnetic manufacture, improved results have been obtained by the large elective companies so that published data regarding the permeability of iron is not available. The magnetic densities at which the iron is worked in the different parts of the motor also affect the permeability of the iron in the different parts of the magnetic circuit.

For the purpose of finding the effect of the iron reluctance with a small air gap assume the permeability of the iron to be 1700 times that of air when worked at 16,000 c. g. s. lines per sq. cm. maximum, or 11,300 c. g. s. lines effective, and that all the iron is worked at this density. The circumference of the secondary is seventy-seven inches, then the distance from the center of one pole to the center of the next pole is 12.8 inches. This is approximately the length of the magnetic circuit in the iron; see Fig. 9.

The length of path in iron is 410 times the length of path in air, but the permeability of the iron is 1700 times that of air. The increase in magnetizing current is $\frac{410}{1700}$, or 24 per cent. This increase in magnetizing current is high because high densities were assumed in the iron, nevertheless, it shows that the iron reluctance cannot be neglected.

Motor dimensions have been assumed without regard for any particular output to be obtained. The motor output and other characteristics will be given in another paper.

Electric Motor Connections

Shunt Wound Motors

By NORMAN G. MEADE

Supplementing the illustrations of Shunt Wound Motors given in the April issue of THE ELECTRICAL AGE, a number of illustrations are given below of the same type.

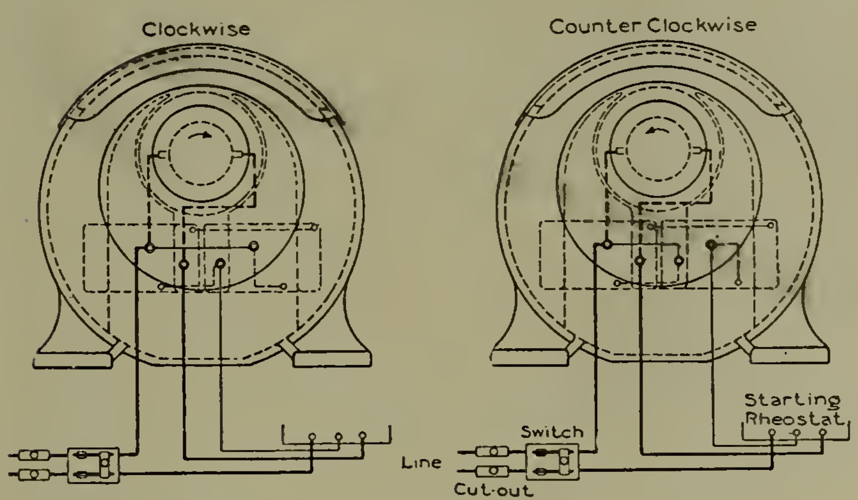


FIG. 50.—FORM B, SHUNT WOUND, C. A. MOTORS. GENERAL ELECTRIC COMPANY.

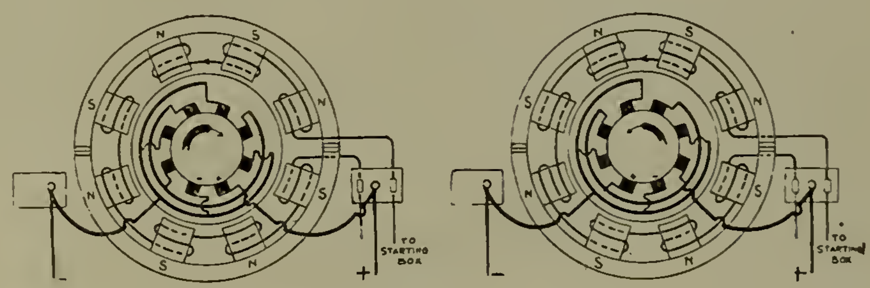


FIG. 52.—8-POLE SHUNT MOTOR. RIGHT- AND LEFT-HAND ROTATION. WESTERN ELECTRIC COMPANY.

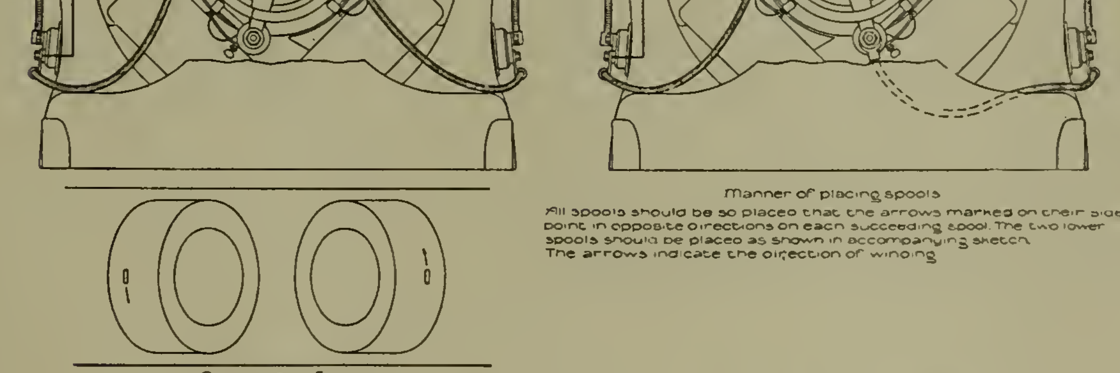


FIG. 51.—SLOW AND MODERATE SPEED SHUNT MOTORS, FORM H. GENERAL ELECTRIC COMPANY.

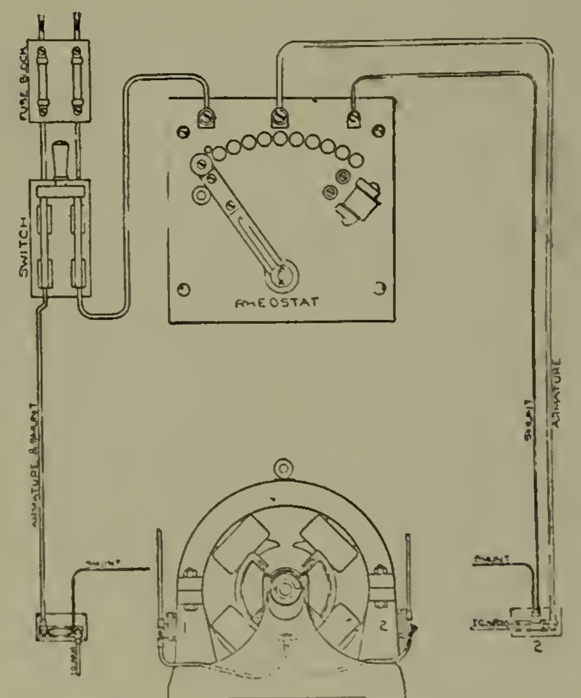


FIG. 53.—CONNECTIONS OF SHUNT MOTOR BUILT BY THE TRIUMPH ELECTRIC COMPANY.

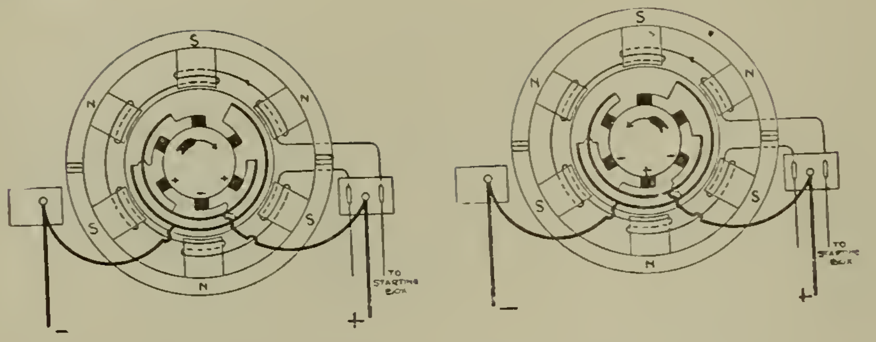
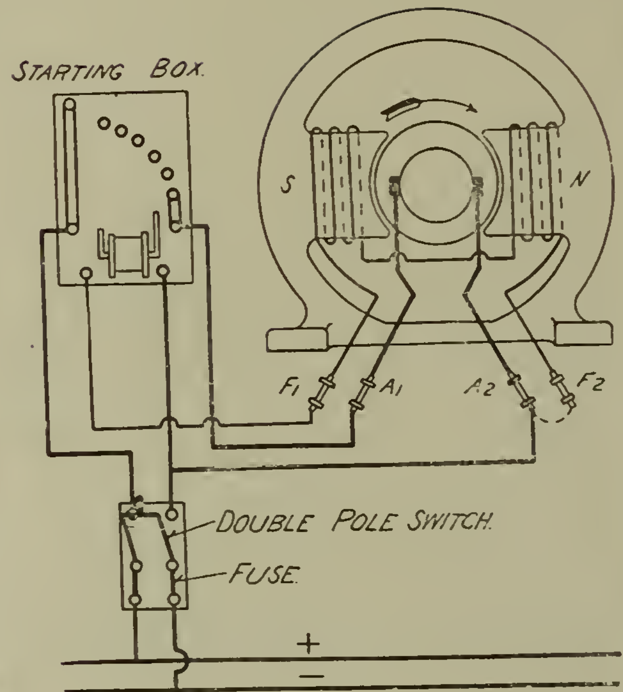


FIG. 54.—6-POLE SHUNT MOTOR. RIGHT- AND LEFT-HAND ROTATION. WESTERN ELECTRIC COMPANY.



Standard Motor connected to Starting Box

FIG. 57.—TYPE "R" SHUNT MOTOR. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

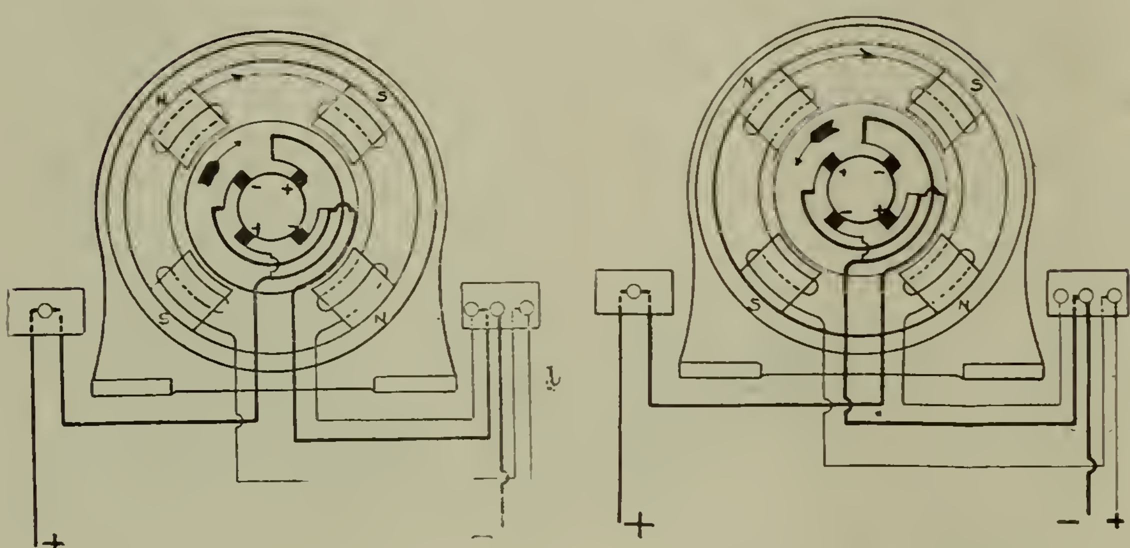


FIG. 55.—4-POLE SHUNT MOTOR. RIGHT- AND LEFT-HAND ROTATION. WESTERN ELECTRIC COMPANY.

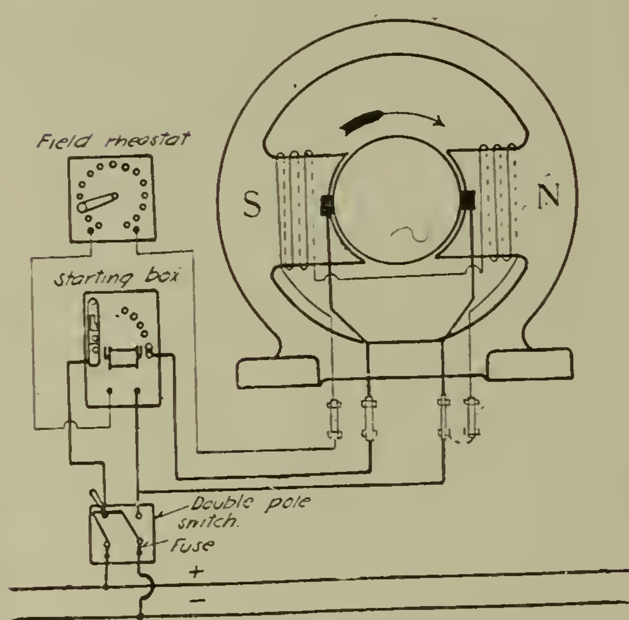


Diagram showing connections of field rheostat.

FIG. 58.—TYPE "R" SHUNT MOTOR. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

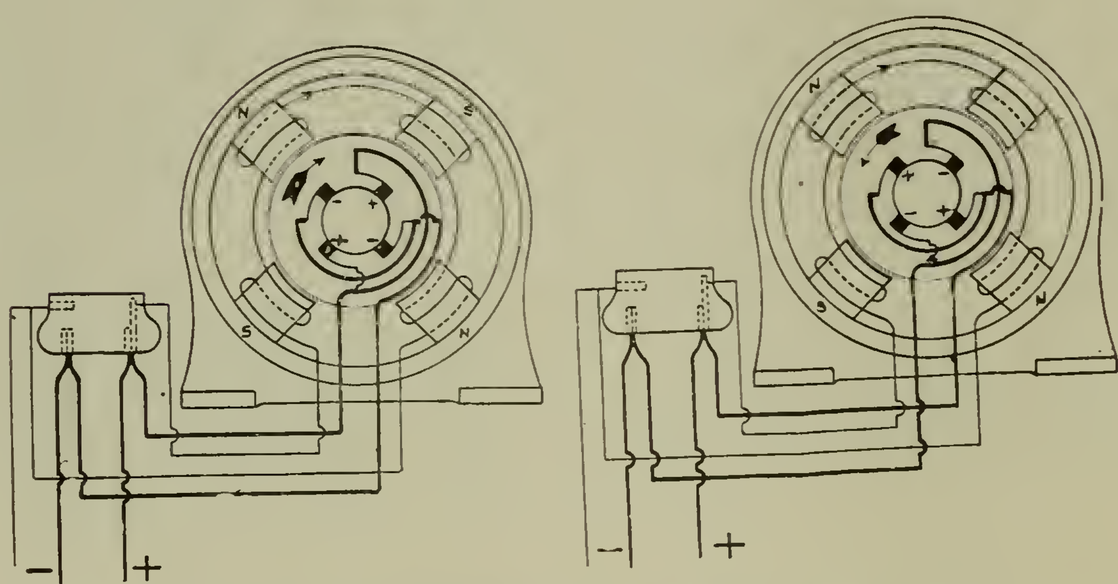
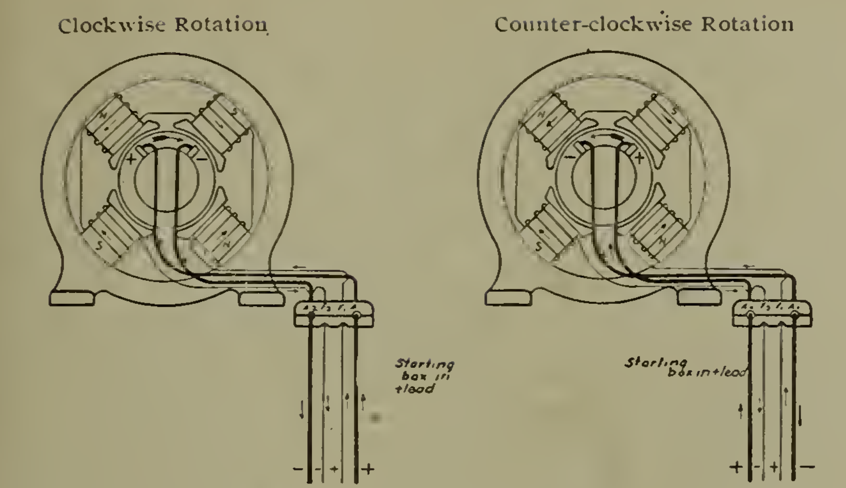


FIG. 56.—4-POLE SHUNT MOTOR. RIGHT- AND LEFT-HAND ROTATION. WESTERN ELECTRIC COMPANY.



Type S Shunt Wound Motors—Frames 7 to 13 Inclusive—Two Brush Arms Seen From Commutator End

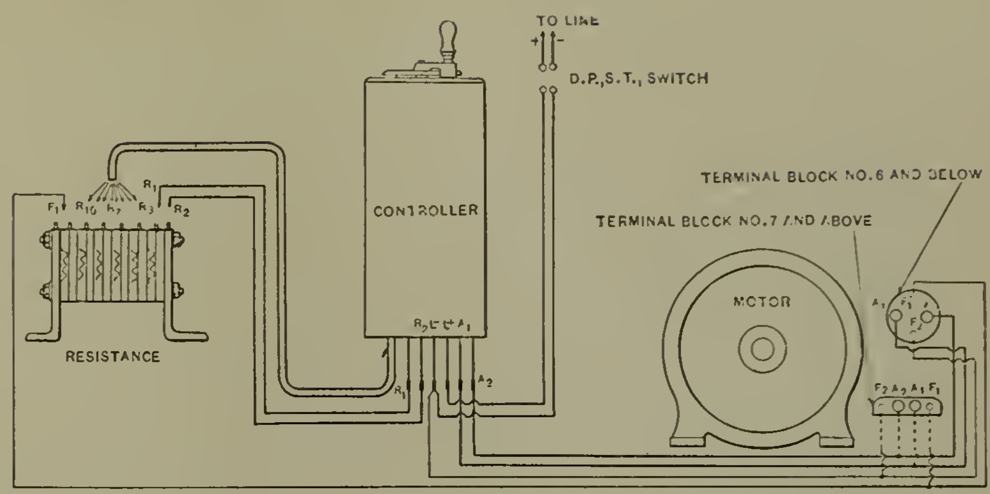
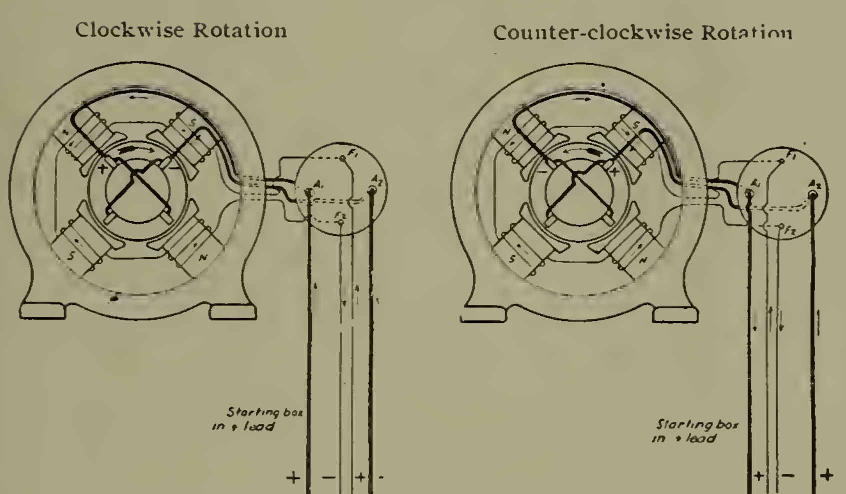


Diagram of Connections of Type S Shunt Wound Motor and Type V Controller and Resistance

NOTE.—The above connections are for clockwise rotation. For counter-clockwise rotation connect A_1 of motor to A_2 of controller and A_2 of motor to A_1 of controller.
For motors of No. 6 frame aud below connect as shown by full lines. For No. 7 frames and above connect as shown by dotted lines.

FIG. 62.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.



Type S Shunt Wound Motors—Frames 1 to 6 Inclusive—Two or Four Brush Arms—Seen From Commutator End

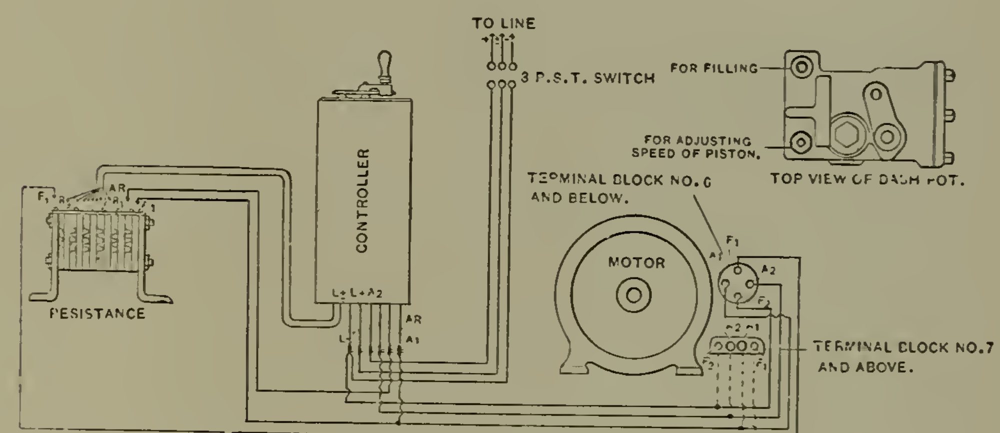
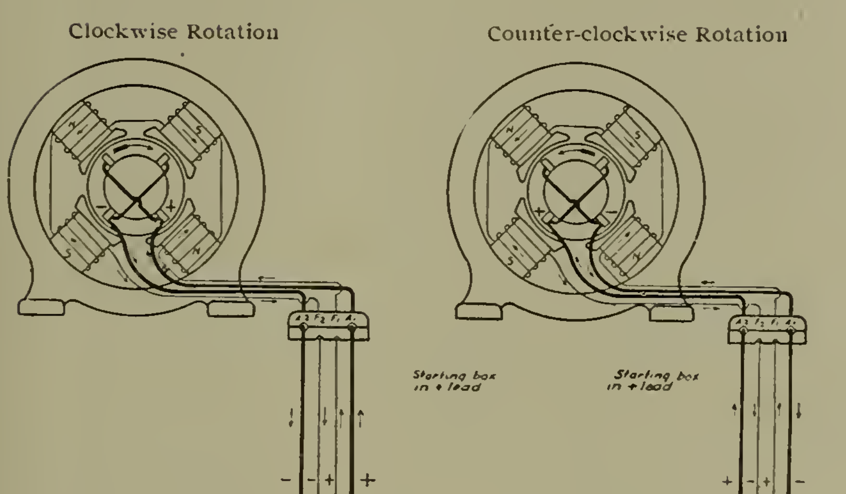


Diagram of Connections of Type S Shunt Wound Motor and Type W Controller and Resistance

NOTE.—The above connections are for clockwise rotation. For counter-clockwise rotation connect A_1 of motor to A_2 of controller, and A_2 of motor to A_1 of controller and A_1 of resistance.
For motors of No. 6 frame and below, connect as shown by full lines. For motors of No. 7 frame and above connect as shown by dotted lines.

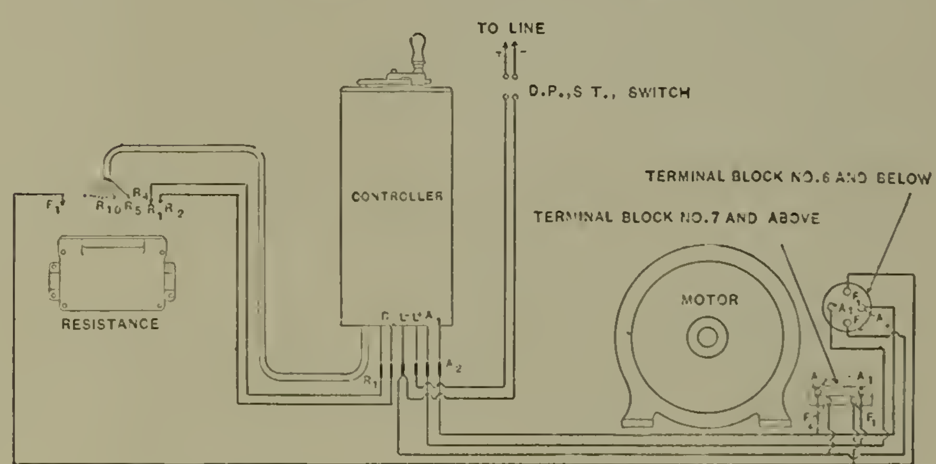
FIG. 63.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

DIAGRAMS OF CONNECTIONS TO MOTOR



Type S Shunt Wound Motors—Frames 7 to 13 Inclusive—Four Brush Arms Seen From Commutator End

FIGS. 59, 60 AND 61.—WESTINGHOUSE SHUNT MOTORS.



CONNECTIONS FOR SHUNT WOUND MOTOR TYPES S AND SA

FIG. 64.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

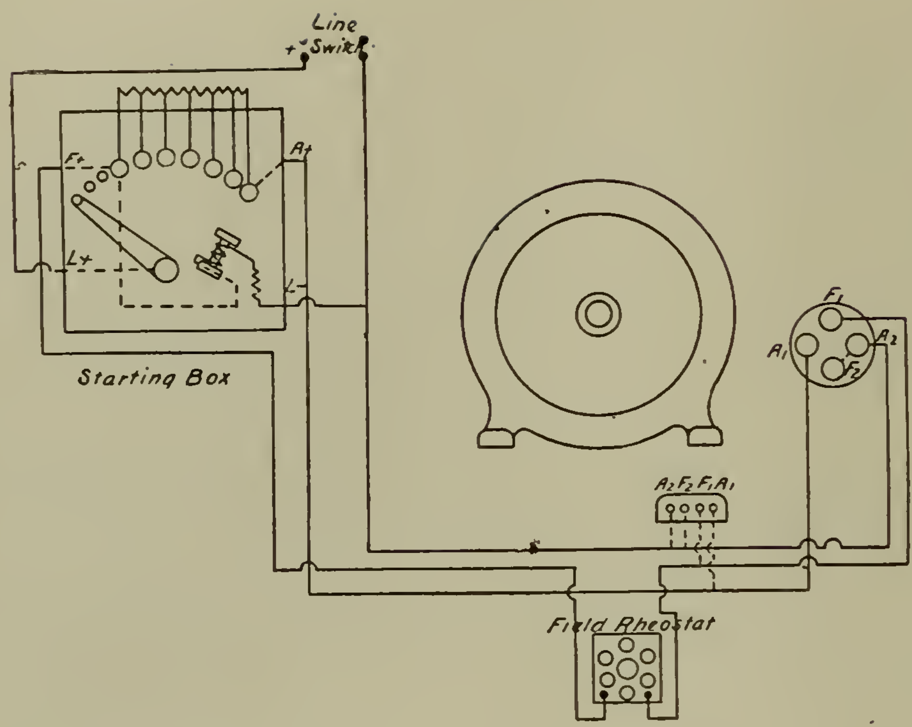
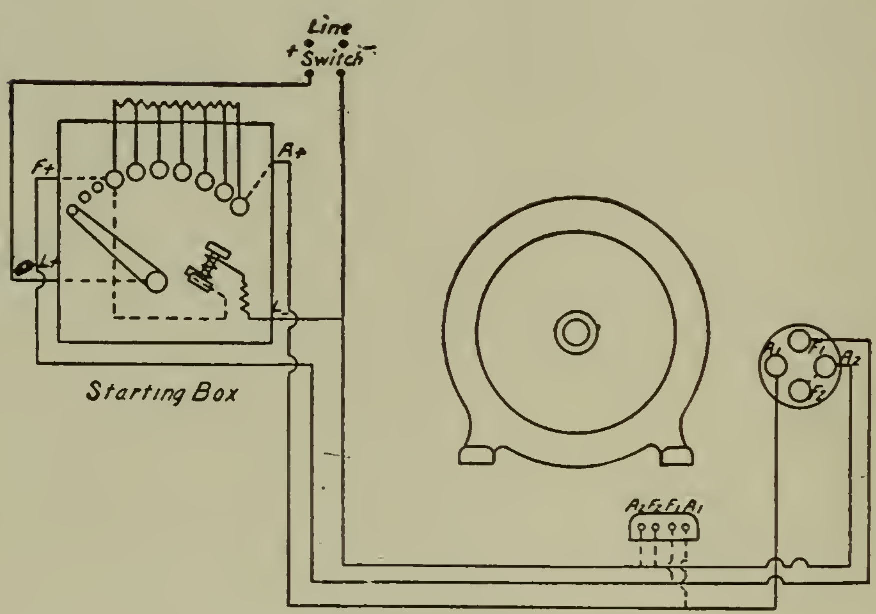


FIG. 65.—CONNECTIONS OF STARTING RHEOSTAT AND FIELD RHEOSTAT FOR TYPE "S" SHUNT MOTORS. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.



Clockwise Rotation

For Frames 1 to 6—Connect as Shown by Full Lines
For Frames 7 and above—Connect as Shown by Dotted Lines

FIG. 66.—CONNECTIONS OF STARTING RHEOSTAT FOR TYPE "S" SHUNT MOTOR, CONSTANT SPEED. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

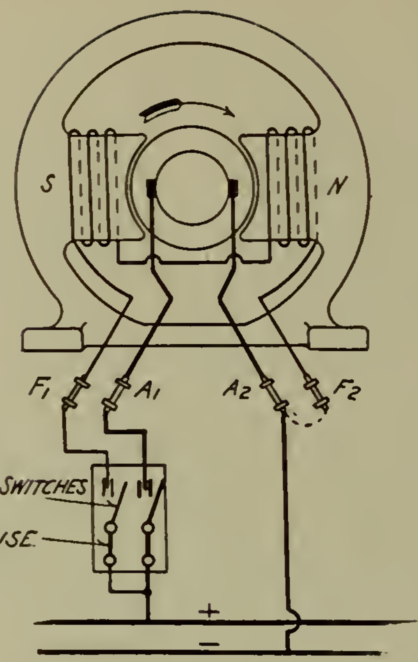


FIG. 67.—CONNECTIONS SHOWING USE OF SINGLE-POLE SWITCHES IN PLACE OF STARTING BOX. WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

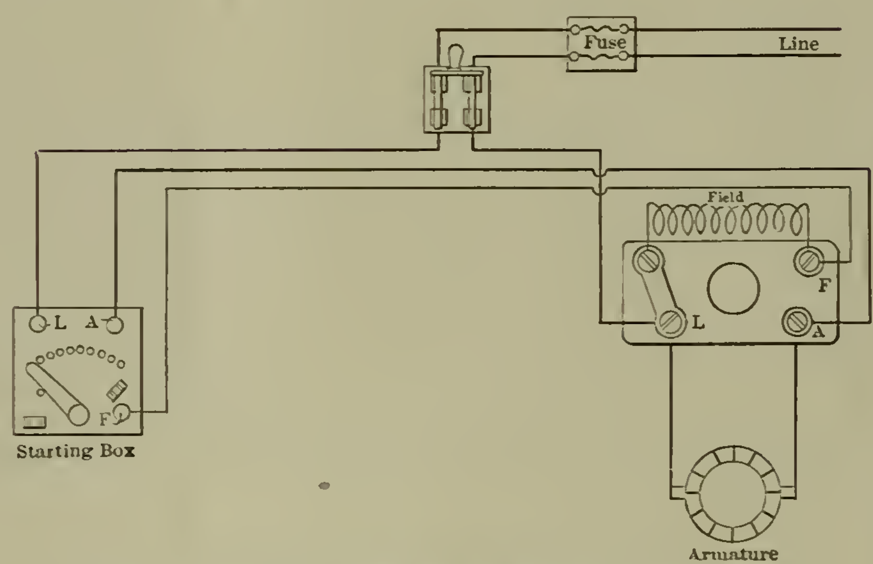


FIG. .—LUNDELL SHUNT WOUND MOTOR, ROUND TYPE SPRAGUE ELECTRIC COMPANY.

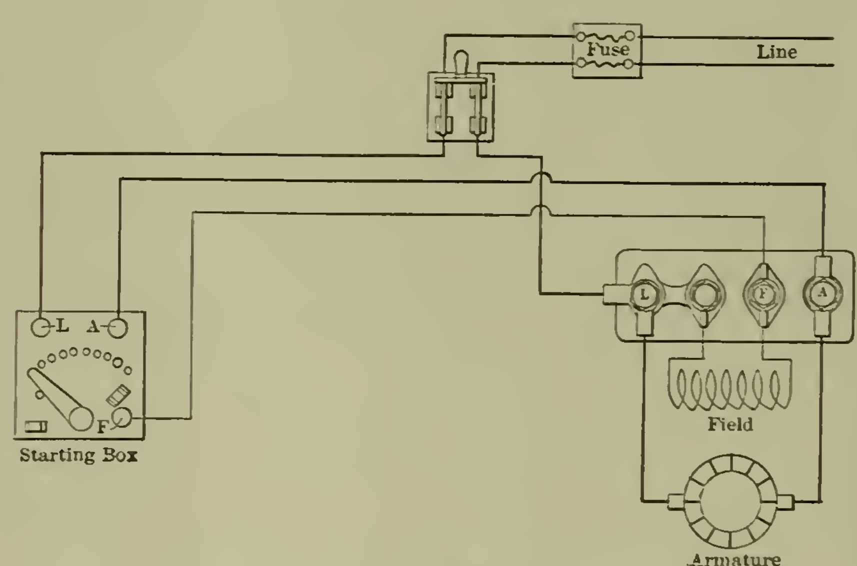


FIG. .—LUNDELL SHUNT WOUND MOTORS, TYPE "R-T." SPRAGUE ELECTRIC COMPANY.

Pole Line Protection on the Elgin and Belvidere Electric Railway

THE Elgin and Belvidere Electric Railway, recently opened up between Elgin and Belvidere, in Illinois, is an excellent example of up-to-date electric railway engineering.

One of its most interesting points is the protection of the transmission line by a ground wire along the entire line. The ground wire consists of No. 6 solid galvanized-iron wire. It is attached to the pole by a lag screw driven vertically into the apex, being held between washers under the head of the screw.

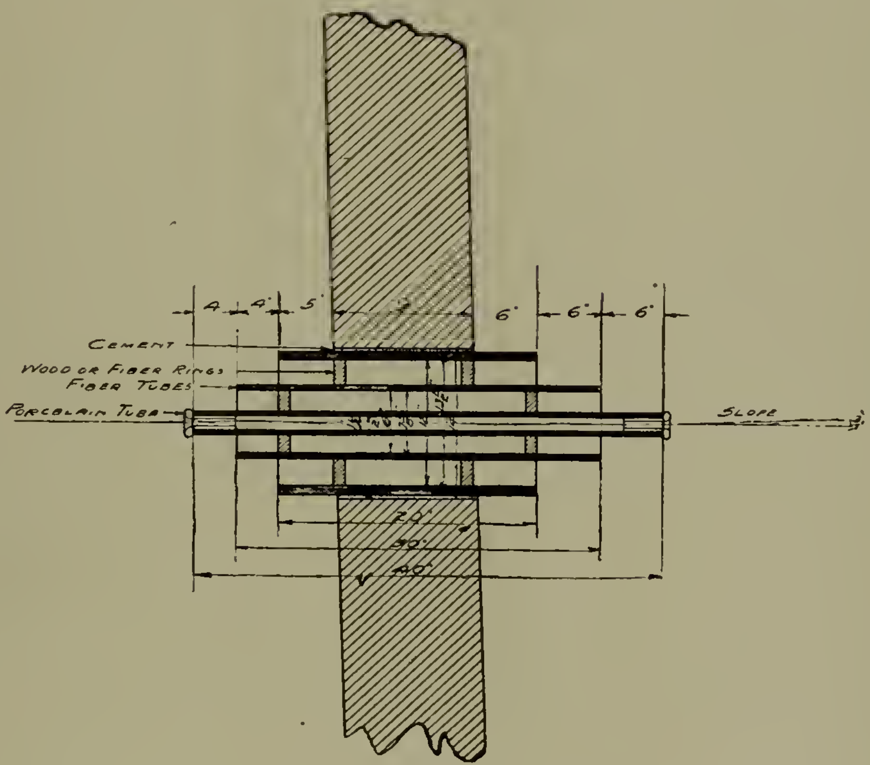


FIG. 1—HIGH-TENSION WALL INSULATOR IN SUBSTATIONS.

The poles are spaced 100 feet, and at every fifth pole, to provide for grounding of the wire, a strip of No. 22 galvanized band iron ¾-inch wide is held at the end beneath the lag-screw washer and led down the pole. It is securely fastened to the pole by nails at 18-inch intervals and comes to an end at the lower extremity of the pole. The ground strip is there riveted to bands of galvanized iron which encircle the base of the pole a few inches apart. At the poles where the ground strip is attached to the ground wire, a piece of No. 6 iron wire is tied to the lag-screw at the top of the pole and left with the end loose and extending upward 6 inches. At the points of transposition the ground wire is supported some inches above the top of the pole by an extension provided for the purpose, this being done to insure proper clearance between the ground wire and the high-tension wires. All guys which extend to within 6 feet of the ground are connected to the ground wire.

Lightning arresters are installed on every twentieth pole in the position shown in Fig. 2. These lightning arresters are of a type designed for 600 volts direct current and are mounted in weather-proof boxes. The ground wire from the arrester is No. 6 B. & S. copper wire, and it is led down the pole along the ground strip and soldered thereto by an effective fastening. At the foot of the pole the ground wire passes into the ballast under the track and connects with a 0000 cross bond attached to both rails. At the Kishwaukee River and at two other points on the line ground plates of ⅛-inch sheet copper, 12x24 inches in size, are buried in the embankment below water level, and connected by No. 0 copper wire to both the ground wire and the rails. The Garton-Daniels Company, who furnished the low-tension lightning arresters, gave the assurance that by virtue of the ground wire and the ground strip, as above described, efficient protection from lightning effects could be secured with the use of only 50 per cent. of the number of arresters that would otherwise be required.

Another interesting detail is the high-tension wall insulators in the substations, illustrated herewith. In bringing the high-tension wires into the substation, two poles are set 15 feet apart with the cross-arms turned to an angle of 45 degrees with the usual plane of the cross-arms. From these cross-arms the high-tension wires pass directly and without other support to the insulators fixed on the brackets on the wall of the substation, thence passing through a tubular insulator set into the wall of the substation. The pole span adjacent to the 45-degree poles is shortened from the usual length, 92½ feet, and guys are provided to brace each pole against

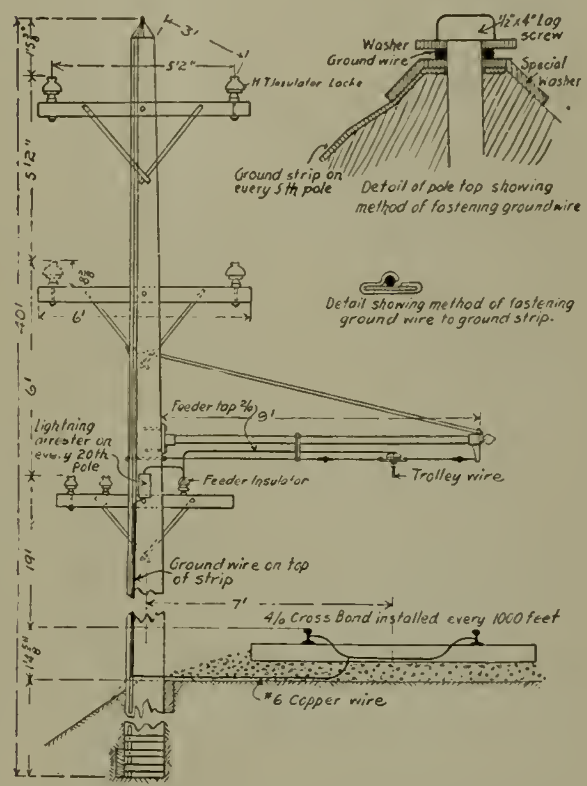


FIG. 2.—DETAILS OF POLE LINE PROTECTION OF THE ELGIN & BELVIDERE ELECTRIC RAILWAY.

the strain in two directions. The tubular insulator referred to is shown in Fig. 1 and consists of triple concentric tubes, the center one of porcelain and the outer ones of fiber, separated from each other by fiber rings. The porcelain tube, through which the wire passes, is 40 inches in length and 1½ inches in diameter; the fiber tubes are respectively 6 inches and 12 inches in diameter and 20 inches and 30 inches in length. The whole unit of tubes is inclined at an angle of ¾-inch to the foot to carry condensed moisture outward.

Beyond these tubes the line conductors pass through lightning arresters and are separated by brick barriers. The main high-tension lines pass out of the building in a manner similar to the incoming lines, the arrangement virtually making a loop of the high-tension lines into the building.

The foregoing facts are taken from a pamphlet issued by the Arnold Company, of Chicago, who had in charge the engineering and construction of the road.

Transmission Lines with Synchronous Motor Load

SYNCHRONOUS motors have been found of so much value in neutralizing the inductance of transmission lines that some companies have installed them for this purpose. It must be remembered, however, that the motor is limited as to output when employed for this purpose. Alternating-current machinery is rated for a definite number of amperes and a given voltage, that is, in k.v.a., and not in k.w. A 100-horse-power synchronous motor will develop 100 horse-power with the field regulated for a power-factor input of 100 per cent. By increasing the field excitation the current input is made to lead the voltage by an angle to give some power-factor less than 100 per cent., depending on the amount of increase above normal. The motor output is reduced directly as the power-factor and the heating is also increased by the abnormal field current.

The effect of the over-excited synchronous motor load on the transmission is to partially neutralize the inductance of the line. If the motor be excited with a field current to give a lead of 10 per cent. power-factor, and it develops its full load at this power-factor, 90 horse-power, the neutralizing effect on the inductance of the line will be greater than if loaded with 100 horse-power and the power-factor is 100 per cent.

The effect of the synchronous motor load on the inductance of the transmission line is shown graphically in Fig. 1. The line *oi* represents the current taken by the load before the synchronous motor is connected. This load amounts to 500 amperes and lags behind the voltage by an angle to give 90 per cent. power-factor. A synchronous motor with full load capacity of 300 amperes can be made to give a total live current with the phase and power-factor, represented by a line drawn between *o* and any point in the circle drawn about *i* as a center with radius equal to 300. The values of current represented by lines between *o* and points in quadrants III and IV correspond to those obtained

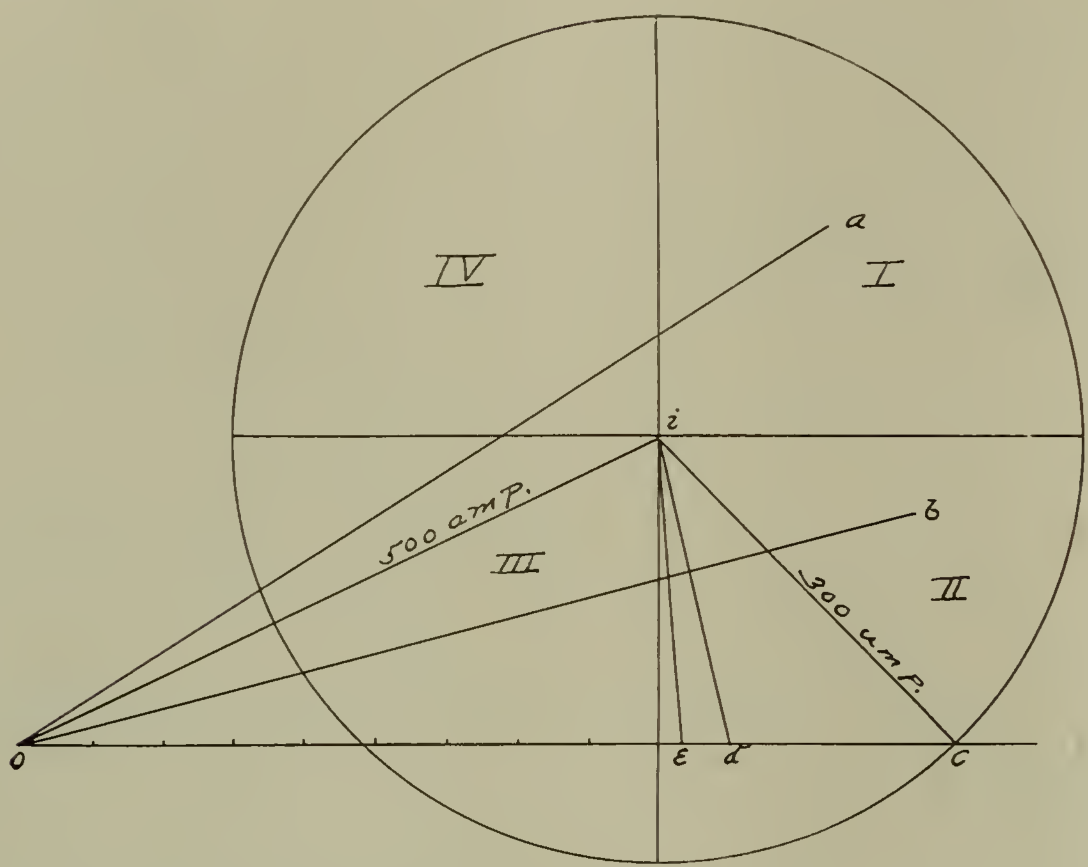


DIAGRAM SHOWING THE EFFECT OF SYNCHRONOUS MOTOR LOAD ON THE INDUCTANCE OF A TRANSMISSION LINE.

when the motor is run as a generator. The current represented by a line drawn from *o* to *a* or to any other point in quadrant I, is obtained by under-exciting the motor. The current represented by the line *ob*, or any line drawn from *o* to a point in quadrant II is obtained by over-exciting the motor. The point *c* is so chosen that the motor delivers its greatest capacity with a resultant line current giving 100 per cent. power-factor, the motor output is 67 per cent. of full load. Unity power-factor may be obtained with any of the current values represented by the lines drawn from *i* to the line *oc*. The line *id* represents a motor current of 225 amperes and a line current of 500 amperes, that is, the line current is not affected numerically by the load due to the motor, and the actual voltage drop on the line is less than before the motor was connected. Another value of motor current is represented by *ic;* this gives a line current less than the current taken before the motor was connected. This peculiar result has been demonstrated a number of times by actual readings of ammeters connected to generator, feeder and motor: the sum of the current on the feeder, 500 amperes, added to the motor current, 220 amperes, gives a load on the generator of 470 amperes; the generator and line capacity are increased by the addition of the motor load.

The greatest effect of the synchronous motor in neutralizing the line inductance is obtained when the motor is running idle. The line *ic* represents the current taken by the motor when the field is greatly over-excited, the power-factor is small and the actual output is small, about 6 per cent. of the motor output, without allowing for losses in the motor.

Methods of Getting New Business

THE getting of new business by means of demonstrations has been so often advocated that any further emphasis along this line might seem superfluous. Some interesting points, however, are given by C. N. Stannard, of Denver, in his contribution to the 1906 prize competition of the Co-operative Electrical Development Association. The demonstrations are classied as follows: *Office*, *Home* and *Church*.

At the office or salesroom the various electrical appliances and devices should be carefully and thoroughly demonstrated. In fact, the last two or three days of each discount period it might be wise to arrange for a competent person to demonstrate electricity as applied to the various domestic uses, showing, among other interesting things, the chafing dish and various electrical cooking and heating appliances. Neighborhood demonstrations can profitably be given in consumers' homes, allowing the consumer to invite a few special friends, the company demonstrator cooking a meal, and using exclusively electrical appliances. In this way very effective advertising may be accomplished.

Church societies are frequently interested in allowing a demonstration to be given in their church parlors or kitchens, at which time various appliances are thoroughly explained. In this way many ladies forming the various church societies become interested and very materially aid in the popularizing of electricity for domestic uses. Ofttimes in interesting churches in demonstrations, as just described, it is found profitable to present the church society, free of charge, with one or more electric appliance.

In organizing this department and carrying forward the work, it is found advisable to first make a house-to-house canvass, carefully carding all prospects, upon the completion of which the company possesses itemized and detailed information showing the amount of possible business to be secured. This information, when tabulated, will be found useful and valuable, and is of particular value when the electric company has competition, either in the form of another electric or gas company. When carded, the names and addresses appearing on the cards provide proper lists to be used in sending out advertising.

Representatives should not only be able to take orders, but possess the ability to sell goods. They should canvass all proposed extensions. One of the most important features of their work is the securing of additional consumption from present consumers. All complaint work should be carefully followed up, and reports made to the office of all poor service, making sure that such service is remedied.

Representatives play a most important part in popularizing the company and in lessening of competition. It is important that they watch all new buildings, making sure that all electrical features are incorporated during their construction, that feeders are of sufficient size to take care of lighting other than the interior system, for instance, sign lighting, window lighting, display and outlining. They should visit architects and builders, interesting them in electricity for both domestic and industrial use.

The holding of business already secured is a most important feature of a representative's work. It is unwise to ever discontinue any business simply upon the request of a consumer, as it will be found in many instances that much business can be held by a representative calling on the consumer. They can aid the advertising work by supplying the one having charge of the advertising with valuable and detailed information.

Specializing weekly is found to be a most profitable way of directing the efforts of the representatives. For instance, on consecutive weeks, it is wise to specialize respectively on signs, outlining, window lighting, power, decorative lighting, additional consumption on present consumers, etc. After specializing a week it is well to have a report of the success attending the efforts on this class of work. It is further found that when specializing, representatives concentrate their efforts, and therefore better results are secured than when working otherwise. It must of course be understood that in doing this work the regular line of work must not be neglected. Many prospects are secured during a week of specializing where contracts are afterwards closed.

It is profitable to assign men to work exclusively upon increasing the consumption of present consumers, explaining to them and interesting them in the installation of additional domestic appliances, also decorative lighting and power, thus increasing the company's revenue very considerably.

The work done by the representatives should be assisted by personal advertising and by the lady demonstrator, providing the company has one in its employ. Consumers are frequently satisfied with simply using electricity for light, but a study of the matter will soon demonstrate to one's satisfaction that the company's revenue may be materially increased through little or no outlay for construction, by making a very careful canvass as above described.

It will be profitable for the company to maintain a portable building, in which should be a complete display of electrical appliances. This building will prove a good advertising medium and through its use many orders may be secured.

The Doherty "readiness-to-serve" rate on electricity when properly presented by the representative will be found a most important factor in increasing the revenue and popularizing the company. This rate also serves to increase the load curve, and is for this and many other reasons of great value to the company.

Upon first thought one only realizes that electricity is applied for the purpose of lighting and power, but the author has assisted in compiling between four hundred and five hundred ways in which electricity is daily being applied. A few of the most important, interesting and novel ways are the following:

Electricity for house cleaning,

Mercury rectifier,

Electromagnets for maturing coffee,

Electric machine for cutting dress patterns,

Arcs for promoting steady and rapid growths of vegetables,

Arcs over oil tanks for bug extermination,

Electricity used in place of an anesthetic for producing insensibility,

Arc and vacuum for taking and printing pictures.

Special features may be incorporated in a representative's work as follows: He should occasionally go over his own business territory at night, thus determining where the dark spots are, and seeking to interest merchants in various forms of display lighting. Again, he may demonstrate to the merchant who has a dark store the value of his neighbors' brilliantly-illuminated windows or stores. Representatives might occasionally go over their neighbors' territories at night, reporting at the next morning meeting suggestions whereby he would seek to improve the conditions found.

The giving of souvenirs is frequently of assistance in increasing the company's business. It is suggested that preference be given souvenirs consuming electricity, such as, for instance, curling-iron heaters, etc.

It is found that each prospect secured serves to assist in developing new ones. It will further be found that the field is inexhaustible. While in some instances the costs to secure new business the first year seems high, the fact must be taken into consideration that the business thus secured remains with the company for years, and is of no further cost. It is not an unusual thing for a new business department to receive in revenue, the first years, three or four times the original investment.

General Electric Company Meeting

THE annual meeting of the stockholders of the General Electric Company, held at Schenectady, N. Y., on May 14th, the following directors were elected: Gordon Abbott, Oliver Ames, T. Jefferson Coolidge, Jr., Frederick P. Fish, George L. Gardner, Henry L. Higginson, Robert Treat Paine, 2d, of Boston; C. A. Coffin, J. Pierpont Morgan, S. L. Schoonmaker, Charles Steele, of New York; W. M. Crane, Dalton, Mass.; Marsden J. Perry, Providence, R. I.; J. P. Ord, Albany, and E. W. Rice, Jr., Schenectady. Marsden J. Perry was elected to succeed the late General Eugene Griffin as first vice-president, and S. L. Henderson to succeed T. K. Henderson, resigned.

At the directors' meeting in New York, on May 15th, the following officers were elected: C. A. Coffin, president; A. W. Burchard, assistant to the president; vice-presidents—E. W. Rice, Hinsdill Parsons, B. E. Sunny, J. R. Lovejoy; M. F. Westover, secretary; H. W. Darling, treasurer and assistant secretary; I. S. Keeler, second assistant secretary; H. P. Schuyler, assistant treasurer; Edward Clark, general auditor; John Riley, assistant general auditor; S. L. Whitestone, assistant general auditor.

The stockholders voted to approve the change in the by-laws providing that hereafter no officer of the company except the president need be a member of the board of directors.

Comparative Tests of the Moore Light and Incandescent Lamps

THE following comparative illumination tests were made in this Assembly Room No. 2 of the United Engineering Building between the Moore tube lighting system, the regularly installed concealed incandescent lamp system and a rectangle formed by rows of exposed incandescent lamps which was the same size as the rectangle formed by the Moore tube. In these tests a General Electric portable illuminometer was used to measure the intensity of the illumination in Hefner feet at nine stations and at a uniform height of thirty-five inches from the floor. Electrical instruments were furnished by the Weston Electrical Instrument Company.

THE MOORE TUBE LIGHTING SYSTEM

The Moore tube, as is well known, is made of clear glass. This particular tube was 176 feet long and formed a rectangle 62½ x 25½ feet. It was 1¾-inch in diameter and was not provided with a reflector of any kind. Nitrogen was automatically fed into the tube, the color of the light being about the same as that of incandescent lamps. Photometric tests showed the tube to require 1.6 watts per Hefner for the 60-cycle street mains. It was operating at 14.8 Hefners per foot, or a total of 2600 Hefners.

The tube having been recently installed had run only some twenty-five hours and had not reached its final efficiency, which should be about 1.4 watts per Hefner after fifty to seventy-five hours' run and thereafter would maintain this efficiency indefinitely.

MEASUREMENTS OF ILLUMINATION, UNITED ENGINEERING BUILDING—ASSEMBLY ROOM No. 2

Station	Moore Tube System	Hefner Feet	
		Concealed Inc. System	Exposed Inc. System
1	4.72	1.72	2.67
2	3.67	2.83	2.37
3	2.90	1.90	2.31
4	2.83	2.40	1.89
5	3.14	1.98	2.07
6	3.83	1.83	2.31
7	4.40	1.61	3.85
8	3.66	1.90	2.47
9	4.00	1.77	2.37
Mean illumination	3.68	1.99	2.48
(Av. Hefner ft.)	3.13		
Power factor	75%	Unity	Unity
Area Sq. Ft.	1930.	1930.	1930.
Watts per Sq. Ft.	2.15	5.31	2.62
Volts	225.	118.	119.
Amperes	24.5	86.4	42.4
Watts Total Illuminating efficiency	41501.71	10250.375	5050.95
Mean Hefner Feet			
Watts per Sq. Ft.			

MEASUREMENTS OF ILLUMINATION UNITED ENGINEERING BUILDING—ASSEMBLY ROOM No. 2
Tests made previous to meeting

Station	Moore Tube System	Hefner Feet	
		Concealed Inc. System	Exposed Inc. System
1			
2	3.67	2.83	2.37
3	2.90	1.90	2.31
4	2.83	2.40	1.89
5			
6			
7			
8			
9			
Mean illumination (Av. Hefner ft.)	3.13	2.38	2.19
Power factor	75%	100%	100%
Area Sq. Ft.	1930.	1930.	1930.
Watts per Sq. Ft.	2.15	5.31	2.62
Volts	225.	118.	119.
Amperes	24.5	86.4	42.4
Watts total	4150.	10250.	5050.
Illuminating efficiency	1.45	.45	.84
(*Mean Hefner feet*)			
(Watts per Sq. Ft.)			

MEASUREMENTS OF ILLUMINATION, UNITED ENGINEERING BUILDING—ASSEMBLY ROOM No. 2
Tests during meeting

Station	Moore Tube System	Hefner Feet	
		Concealed Inc. System	Exposed Inc. System
1			
2	3.2	2.7	1.44
3	2.72	2.7	1.11
4	2.33	3.8	1.22
5			
6			
7			
8			
9			
Mean illumination (Av. Hefner ft.)	2.75	2.97	1.25
Power Factor	72%	Unity	Unity
Area Sq. Ft.	1930	1930	1930
Watts per Sq. Ft.	1.97	5.61	2.41
Volts	228.	119.	117.
Amperes	23.	91.	40.6
Watts total	3800	10840	4650
Illuminating efficiency	1.4	.52	.52
(*Mean Hefner feet*)			
(Watts per Sq. Ft.)			

THE CONCEALED INCANDESCENT LAMP SYSTEM

The tubular 8-candle-power 119-volt incandescent lamps were located behind a cove. A two-way socket was located every sixteen inches, therefore 288 lamps were in use. Immediately behind each lamp was a Frink reflector. The lamps and entire equipment were new, having only been used a very few hours. Equally spaced on the longitudinal center line of the ceiling of the room were located three incandescent clusters, which were concealed by opalescent reflectors, each containing six lamps of 25-candle-power. This incandescent concealed lighting has been admirably done and represents the highest achievement of the art of so using incandescent lamps.

THE EXPOSED INCANDESCENT LAMP SYSTEM

The temporary circuit of incandescent lamps was installed to parallel the tube throughout its length. It therefore was located close to the tube between the latter and the edge of the cove, so that all of the lamps were exposed and not shielded in any way. They were all new 3.5-watt 117-volt incandescent lamps, purchased from the General Electric Company by the Public Service Corporation of New Jersey and loaned for this test. They were spaced twenty-four inches apart and therefore ninety were in use. Each lamp was in a vertical position.

The tables on this page give the illumination readings for each of the three systems taken at stations around the room. They were made by Mr. C. M. Axford, of the General Electric Company, using the same luminometer which was referred to in the paper.

The electrical measurements were made by Mr. Nelson Goodwin, Chief Engineer of the Weston Electrical Instrument Company, using recently calibrated Weston instruments.

For convenience in comparison a table of the readings on the same three stations is abstracted from the complete test made previous to the meeting.

It would seem that the illuminating efficiency agrees closely with the former test for the tube system and the concealed incandescent system. The exposed incandescent system, however, is 61 per cent. lower because in the first test the volts were above the rated voltage of the lamps. This serves to illustrate forcibly a well-known characteristic of the incandescent lamp, *i. e.*, their rapid falling off in efficiency with a drop of voltage, for it will be noticed in the first test the volts were 119 as against 117 in the second. The latter being the rated voltage of the lamps represents the true efficiency based on these three stations.

Moreover, since the same ratio would hold for all stations the illuminating efficiency .95 given in the complete should be .6, which would make the tube system about three times more efficient than the exposed incandescent system in this particular case, and after the end of fifty hours' run, when the tube will have an efficiency of 1.4 watts per Hefner, the ratio will be 1 to 3.4. Finally after 500 hours' run, when the average efficiency of the incandescents will be about 4.5 watts per Hefner, the tube would show an illuminating efficiency over four times that of the exposed incandescent lamps.

It will also be noted that neither similar change in the tube voltage nor a considerable change in the tube watts due to adjustment of the gas valve has materially altered its illuminating efficiency.

The complete test covers symetrically one-quarter of the room, which is also symetrical, and therefore represents accurately the average illumination of each system. Therefore a room of this kind can be lighted by the Moore tube for one-fourth the cost at which it can be done by incandescent lamps.

CONCLUSIONS

The conclusions drawn from the tests are as follows:

First.—That the Moore tube lighting system has 4.6 times the illuminating efficiency of the concealed incandescent lamp system as installed under these local conditions. The Moore tube produces 85 per cent. more useful illumination, yet requires 60 per cent. less wattage than the incandescent lamp system.

Second.—That a rectangle of Moore tubing has 1.5 times the illuminating efficiency of a rectangle composed of incandescent lamps. The tube produces 57 per cent. more useful illumination, yet requires 18 per cent. less wattage. It was noted that the intrinsic brilliancy of the exposed incandescent lamps was too great; but not so that of the tube.

The average watts per candle-power of incandescent lamps is not better than five. Therefore under average commercial conditions the tube would have shown its superiority over exposed incandescent lamps on the basis of two to one.

Trade News

The largest order for alternating-current generators ever placed by one interest with any manufacturer of electrical apparatus in this country has recently been awarded by the United States Steel Corporation to the Allis-Chalmers Company, Milwaukee. The Milwaukee company has received orders for thirty-two gas-engine-driven electric generators, aggregating 68,000 k. w., sixteen of which are to be installed in the new plant at Gary, Ind., now in course of construction by the Steel Corporation. The other sixteen units are for the Homestead plant of the Carnegie Steel Company, the South Chicago and Bay View (Milwaukee) Works of the Illinois Steel Company, and for the central furnaces of the American Steel & Wire Company, at Cleveland, O.

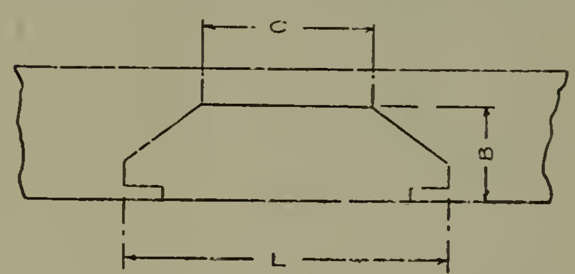
The Edison Illuminating Company, Detroit, have installed in their Beecher Avenue substation a 25-ton electric Northern crane, manufactured by the Northern Engineering Works, of Detroit, Mich.

The Steel City Electric Company, manufacturers of the well-known bushings and floor boxes, have been obliged to remove from their old quarters at Third Street and Penn Avenue, Pittsburg, to a large building entirely occupied by themselves at 1207-1219 Washington Avenue, Allegheny, Pa.

The Philadelphia Electric Company is removing its general offices, formerly at the corner of Tenth and Sansom Streets, to Tenth and Chestnut Streets, at which corner the company has erected a steel frame fireproof structure, seven stories high, fronting thirty-two feet on Chestnut Street and 229 feet on Tenth Street. The main entrance of the building is on Chestnut Street, opening into a dignified and imposing display room, which will be used to exploit everything which is new and useful in light and heat work. Immediately beneath this display room in the basement will be a room of corresponding size for exhibiting various types of electric motors, together with a number of the more important mechanical devices. The basement will also contain a dark room where all of the various types of electric light will be exhibited.

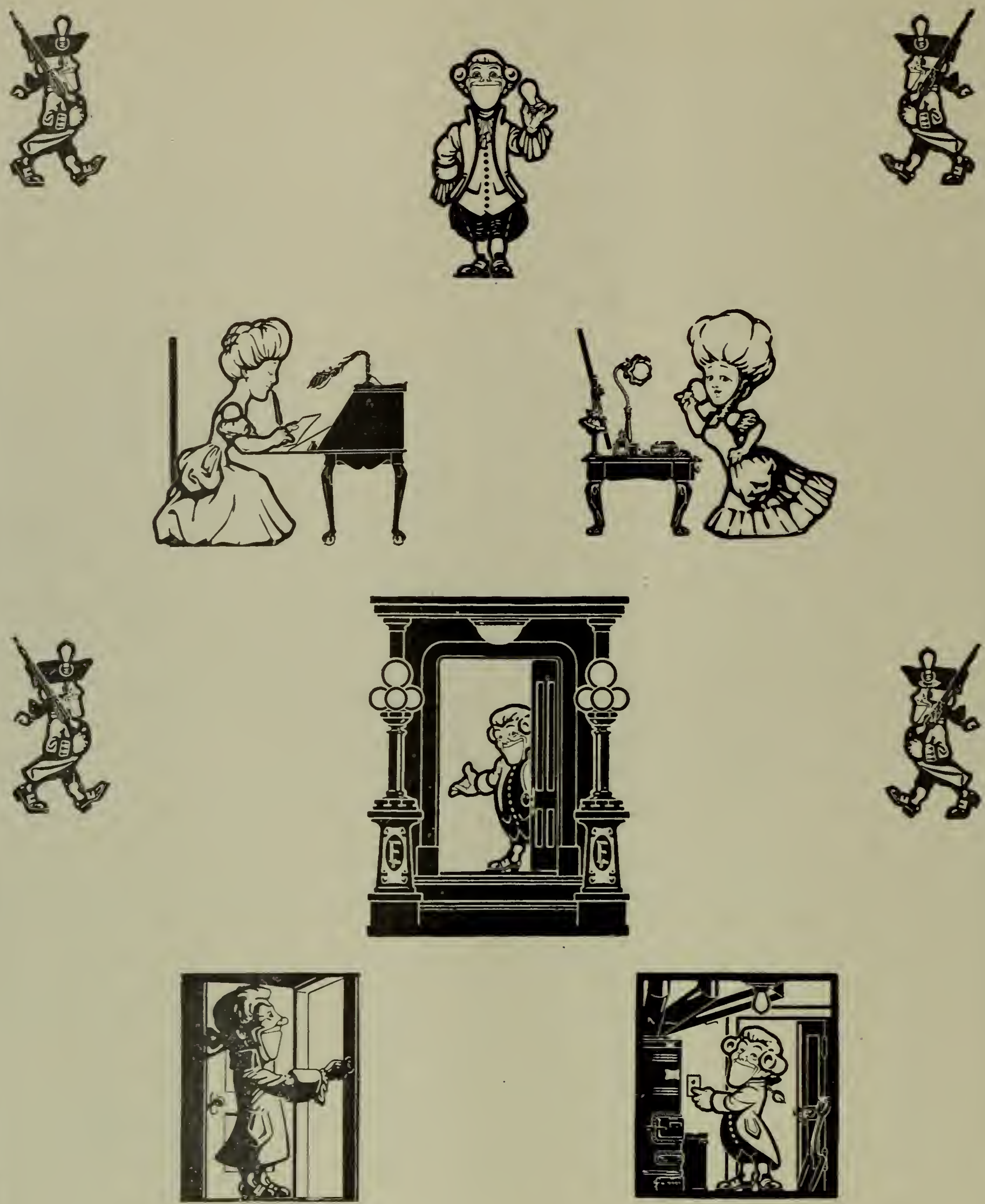
Underground Conduit Systems for Power Work

In the May issue of THE ELECTRICAL AGE one of the illustrations was omitted in the article on "Underground Conduit Systems for Power Work." The illustration, given herewith, shows a side-wall type of splicing chamber, which is entered from the side instead of the top. This form is used in the side walls of tunnels or in retaining walls, and usually takes the form of a long niche in the wall. When built in tunnel walls not far from the surface of the ground, it is desirable to have such chambers open from the street above as well as



A SIDE WALL TYPE OF SPLICING CHAMBER. ENTERED FROM THE SIDE INSTEAD OF THE TOP. SEE ARTICLE ON "UNDERGROUND CONDUIT SYSTEMS" IN MAY ISSUE.

from the side, in order to avoid the necessity of having the use of a tunnel track when work is to be done in the chambers.



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Editorials

Leading Articles

A Source of Energy Loss in Power-Houses

WHEREVER in a power-house or substation alternating-current is conducted by means of single cables instead of triplex cables, care must be exercised to prevent loss of energy wherever the cables run near iron-work or when it is necessary to clamp the cables to the wall. In a central station in one of our large cities, part of the cables were run singly up a wall and clamped every ten feet or so by means of iron straps bolted to an angle fastened in the wall. Everything went on all right, apparently, until a workman attempted to remove one of the clamps, with the result that his hand was burned.

On investigation, and after some thought, it was apparent that the iron strap, bolts and angle acted as the shell of a shell-type transformer and the combined hysteresis and eddy-current loss was appreciable even in one clamp. With a clamp every ten feet on each single cable, the loss in energy would doubtless be considerable. The trouble was overcome largely by grounding the cable sheath and the clamp, for this purpose a copper strap being placed near each clamp, which, with the strap, was grounded to the iron-work of the building.

A better way, of course, would have been to anticipate the difficulty and to provide a clamp which would break the magnetic circuit. This can be done by using a porcelain bushing around the cable and fastening the strap by means of gun-metal bolts.

In the use of concrete slabs, also, in place of slate or alberene stone for switch compartments, septums in pulling boxes, or the like, care must be taken to see that the reinforcing is parallel with the length of the cable, as, if it be at right angles, the tendency to the production of eddy currents and hysteresis loss will be increased.

It is for the same reason that, while iron pipe may be employed for carrying triplex cables, vitrified duct or fiber conduit must be used for single cables carrying alternating current.

The N. E. L. A. Programme

IN an editorial in the issue of June 22d, our esteemed contemporary, *The Electrical World*, offers some timely suggestions regarding the length of the programme for future conventions of the National Electric Light Association. We wish to add a few words here regarding the advisability of some change in the present method of presenting papers and discussing them.

Two courses of action appear to be open: first, making the number of papers small, having them read or abstracted and discussed, or, secondly, having the number of papers large, without having them read or even abstracted, and taking up the time solely with the discussion.

The first arrangement seems to us the better one. Discussion is stimulated by first presenting a number of points in a paper, so as to suggest to the hearers cases in their own experience or questions on which they wish enlightenment. It has been suggested that the members take home the papers and fully digest them there, rather than at the convention. This will be done in any event, but the members will probably find after they have reached home that they neglected to ask a question on an important point if they fail to read the paper at the time of its presentation.

Another course suggested by our esteemed contemporary seems open, namely, dividing the convention into sections for the simultaneous presentation and discussion of different papers in different rooms. This will work well in some cases, but with the managers of small plants who must, of necessity, be the head of the business department and of the operating or engineering department as well, it will be a somewhat difficult matter to so dispose himself as to be present in two places simultaneously.

However, some change must be made if the most important points of the topics are to be brought out, and our contemporary has started the ball rolling in the right direction.

Testing Fireproof Cables

THE form of fire-resisting cables most commonly met with consists of the usual copper conductor insulated with pure and vulcanized india-rubbers, over which is a fire-resisting protection, consisting of either tapes specially treated so as to render them incombustible, or of braiding consisting of similarly treated threads of cotton, jute, hemp, or other fiber. While these cables are more or less satisfactory, they are scarcely to be regarded as the ideal, for, in the event of an internal arc being formed in the copper conductor, caused, for instance, by a breakage of the insulating rubber, the intense heat generated will cause the rubber to liquefy, and even assume the gaseous state, and will, before long, burst into flames.

In a recent issue of *Electricity and Electrical Engineering*, of London, some interesting particulars are given of tests of fireproof cables made at the works of Johnson & Phillips at Charlton. The cables were constructed as follows:

Next to the copper conductor is the ordinary taped rubber insulation; over this there are several laps of the highest quality Manila paper, impregnated with a special harmless fluid in such a way as to be uninflammable. In fact, it was stated that if a flame is brought into contact with the material, it will give off gases in which a flame cannot exist. Over this is a strong but flexible braiding of small steel wires, these in turn being covered with several more laps of the same specially prepared uninflammable paper. The cable is finally covered with a braiding of specially impregnated jute, and finished with a fire-resisting compound specially prepared in the firm's laboratory.

The tests carried out on May 30th were six in number. First a short length of this cable was placed over a Bunsen flame for half an hour, while a pressure of 220 volts was maintained between the steel protection and conductor; the insulation did not catch fire, but simply attained a high temperature. The cable was then removed and struck three heavy blows with a 2-pound hammer. On measuring the insulation resistance it was found to be 75 megs, the testing battery used having a pressure of 500 volts. After dealing the cable several more heavy blows, it was finally quite flattened, which brought the wire protection in contact with the conductor, thus causing a short-circuit, which blew the fuse.

The second test consisted of placing a piece of cable in a Bunsen flame as described above, but in this case it was not connected with the electric supply. While in the flame five insulation tests were taken, at five-minute intervals. Each test showed the insulation to remain practically constant at 75 megs. After this a pressure of 3000 volts was applied to the cable, but it failed to break down.

To show that an arc taking place inside the insulating material of a cable of this description cannot set it on fire, an ordinary piece of fireproof cable was employed, but an arc lamp carbon was substituted for the copper conductor, this carbon being broken in the middle. A current of 60 amperes at 200 volts was then sent through the cable which set up an arc between the two broken pieces of carbon. The arc was allowed to continue for twenty minutes, and at the end of this period the cable was red hot, but it did not take fire. The same test was also made with 90 amperes for five minutes, but the same satisfactory results followed, viz., no fire. Another test conducted on exactly the same lines, but with an ordinary braided cable, proved exceedingly interesting, for the moment the current was switched on there was a loud explosion, and the cable burst and caught fire.

The fifth test consisted of overloading a 3.22 fireproof cable (having a normal carrying capacity of about 3 or 4 amperes) with 100 amperes. After the current had been flowing for about two minutes the conductors fused, but the insulation remained practically unaltered. The same experiment carried out with a 3-22 ordinary braided cable resulted in melting the wax compound in a few seconds after the current was switched on, and shortly afterwards the cable was in flames.

Commutating Poles

THE use of commutating poles in variable-speed motors has been rather extensively discussed in the past and yet the subject has not failed in interest; in fact, the use of auxiliary poles in the design of a railway motor by one of the large manufacturing companies has again drawn attention to this means of obtaining sparkless commutation; hence, our excuse for giving here some points brought out in a paper by F. H. Page and F. J. Hiss, read recently before the British Institution of Electrical Engineers.

In summarizing the conclusions obtained from their investigation, the authors point out that the heating limits will remain the same whether interpoles are employed or not, and it is only by a better distribution of the losses and a different proportioning of the various parts of the machine that an economy can be effected. For the very small sizes it is probable that it will not be found of much advantage to adopt commutating poles as a standard. The extra labor cost entailed in fitting commutating poles is of considerable consequence, the available space between the poles is constricted, the total number of field coils would be doubled, and, as the heating limit is reached before the sparking, advantage cannot be taken of the saving in material, which is effected in large machines by a reduction in the length of the air-gap and so forth. Only machines above 40 k. w. to 50 k. w. output will therefore be considered.

It does not appear desirable to increase the number of poles with the new designs. Although a considerable saving may be effected in amount of material used, yet the general sensitiveness of a machine with an abnormal number of poles fits it rather for laboratory experiments than for practical working, especially under adverse conditions.

At first sight it would appear that a considerable saving would be effected in field copper by slightly increasing the core length of the machine and reducing the high flux-densities in the teeth. This is possible, as one is no longer restricted in length by commutation conditions. A limit is, however, soon reached, beyond which a further increase in length is not economical. If this be exceeded it will pay to increase the densities again until the increased cost of copper as a per cent. of the total cost just balances the per cent. increase in output. This density seems to be about 19,500 to 20,500 lines per square centimeter.

It must not be forgotten that increased armature ampere-turns will necessitate more interpole turns and that therefore there must be a certain point beyond which it will not pay to increase the rating, even if there is ample room in the slot. This limit is reached when there are from 300 to 360 ampere-bars per centimeter of armature circumference, the figure to be taken depending on the size of the machine.

In the choice of windings one has now a much freer hand; a series winding can often be employed where formerly commutating conditions would necessitate a parallel one. With interpole machines preference should always be given to a series winding, as its self-equalizing properties are very valuable with the short lengths of air-gap employed. Another important feature is that the variation in commutating flux is less with the series winding.

Series parallel windings should be avoided, as they usually lead to heavy equalizing currents flowing under the brush from winding to winding. The only time when they can be employed with good results is with eight or a larger number of poles, a doubly re-entrant or a duplex winding having been used with excellent results by one of the authors on several occasions. A doubly re-entrant winding is best with an 8, 12, or 16 pole machine; a duplex with a 10, 14, or 18 pole.

The Induction Motor

PART III

By C. J. SPENCER

THE direct calculation of induction motor performance from equations containing primary and secondary resistances and reactances is possible, but is tedious. Moreover, the reactions are not so readily understood, as when the method given below is followed.

Any current may be assumed as flowing in the secondary. The volts drop due to the secondary resistance and reactance can be at once calculated, the required magnetic flux to give this voltage can also be calculated, the primary current necessary to overcome the demagnetizing effect of the secondary and in addition to produce the magnetic flux for inducing the secondary voltage is derived from the motor constants and the volts drop due to primary resistance and reactance with this primary current is added geometrically to the back electro motive force induced in the primary by the magnetic flux. The total voltage may not be the impressed voltage for which the motor is designed, but these results are all proportional to the impressed voltage, that is, the current, magnetic flux and voltages in the different parts of the motor are proportional to the impressed voltage; they can then be found by making proportional reductions throughout.

Another possible method is to assume a strength of magnetic flux, which method gives results very close to actual on the first assumption, as the magnetic flux does not change rapidly with change of load. This method, however, increases the length of the secondary calculation.

Suppose the motor constants have been calculated as per methods given in parts I and II and are as tabulated below. The term "volts drop per ampere" is introduced in place of henrys, since the voltage given is for a 60-cycle circuit only.

Primary resistance=.274 ohms.

Primary reactance=.357 volts drop per ampere.

Secondary resistance=.000196 ohms.

Secondary reactance at 100 per cent. slip=.0000786 volts drop per ampere.

Magnetizing turns of primary=60 turns.

Demagnetizing turns of secondary=4.3 turns.

The demagnetizing turns of the secondary is the sum of the current values in the different bars in any one pole space.

Assume a secondary current of 520 amperes and find the motor performance at 7.5 per cent. slip. The secondary resistance is .000196 ohms, then the drop in voltage due to resistance is

.000196 ohms x 520 amperes=.102 volts.

The secondary reactance is 7.5 per cent. of that at standstill when running at a slip of 7.5 per cent., since the frequency of alternation in the secondary is 7.5 per cent. of that at standstill, then the secondary drop in voltage due to reactance is

.075 x .0000786 x 520 amperes=.00307 volts.

These voltages are represented in Fig. 1, as is also the angle of lag of

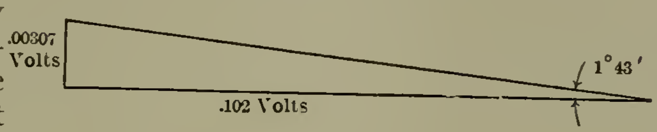


FIG. 1.

current behind the voltage. The angle of lag is found from its tangent, which is equal to $\frac{.00307}{.102}$ =.0301 and a table of natural tangents shows this angle to be 1°43′.

The natural cosine of 1°43′ is .9996, or so close to unity that it may be taken as unity without error. Since the cosine of the angle of lag is taken as one and the drop due to resistance is .102 volts the total voltage drop in the secondary is $\frac{.102}{1}$ =.102 volts. If the angle of lag had been greater than that here found, as will be the case with large slips, the cosine would be less than unity and the total voltage drop would be greater than that due to resistance alone.

The rotating magnetic field cuts the bars of the secondary at a frequency 7.5 per cent. of 60 cycles, since the slip is 7.5 per cent., and the required magnetic field to produce the voltage necessary to force the current of 520 amperes through the secondary is found from the formula

.102 volts x 10^8= 2π 60 cycles x .075 x B

where B is the total number of c. g. s. lines per pole,

B=360000 c. g. s. lines.

In finding the magnetizing current for this motor as per method given in part II, a primary current of 17.8 amperes was found to produce a field of 417500 c. g. s. lines, therefore the magnetizing current for the above field will be

$\frac{360000}{417500}$ x 17.8=15.3 amperes.

There are the equivalent of 60 turns per leg in the primary, giving with the above current a magneto motive force equal to that produced by 918 ampere turns. This is opposed by a demagnetizing force from the secondary current amounting to 2240 ampere turns, with a current of 520 amperes and 4.3 turns. The magnetic flux is 90 degrees ahead of the induced voltage and in phase with the magnetizing current and the voltage induced in the secondary leads the secondary current by an angle of 1°43′, which gives a total angle between the apparent magnetizing current and the secondary current of 91°43′. I say apparent magnetizing current, for there is but one current in the primary and values are given to what is called the magnetizing current for the purpose of calculation only. From this data we obtain Fig. 2. which represents the opposing ampere turns and their resultant. A magneto motive force must be produced by the primary, which will overcome the secondary magneto motive force and give a resultant of 918 am-

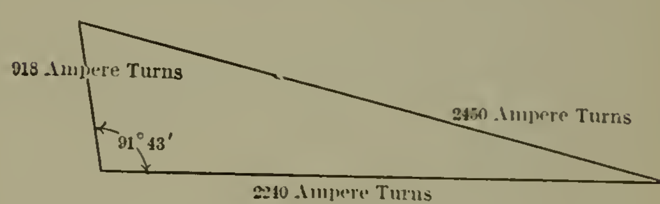


FIG. 2.

pere turns. This value is found by the use of any of the well-known trigonometrical formulæ and is 2450 ampere turns. The primary turns has been found to be the equivalent of 60 turns, giving a required primary current of

$\frac{2450}{60}$ =40.8 amperes.

An electro motive force is induced in the primary by the same field which produces the secondary voltage and is found to amount to 244 volts. This voltage lags behind the inducing field by an angle of 90 degrees. The angle between the inducing field and primary current can be found from Fig. 2. This angle is 66° 16′, giving a total angle between primary current and induced voltage of 156° 16′, or what is the same thing when positive and negative signs are neglected 23° 44′.

A current of 40.8 amperes was found in the primary, giving a resistance drop in potential of

40.8 x .274 ohms=11.14 volts,

and a reactance drop in potential

40.8 x .357=14.55 volts.

All of these voltages are laid off at their respective angles in Fig. 3. The geometric sum of these voltages is obtained by completing the right

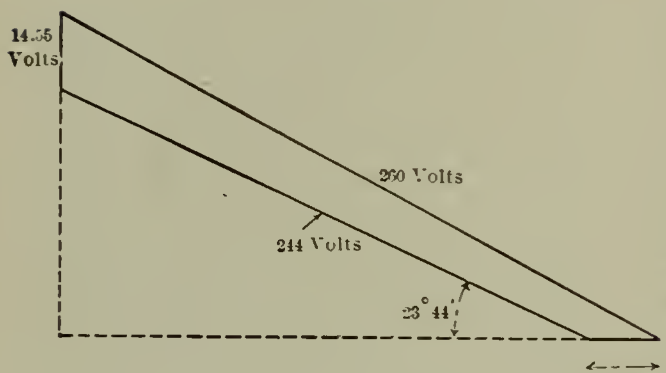


FIG. 3.

angle triangle, as shown dotted and amounts to 260 volts.

This particular motor happens to be delta connected, and the voltage of the circuit is 200 volts effective or 283 volts maximum. All of the above values are expressed as maximum values.

The required impressed voltage is 260 volts maximum, neglecting iron loss; friction and windage must be considered as a part of the motor output and must be deducted from the developed power. Every calculation up to this point has been approximately in ratio to the secondary current. If the current in the secondary be increased or decreased, the resistance and reactance drop in potential in the secondary will be increased or decreased, the triangle shown in Fig. 1 will be increased or decreased; the angles remain the same, the lengths of sides are changed. With an increase or decrease in voltage drop through the secondary, the magnetic flux required to generate the voltage is increased or decreased. The magnetizing current, however, is not exactly in direct ratio to the magnetic flux, owing to reluctance of the iron changing with change of magnetic density. The magnetizing current is relatively small at large overloads where the magnetic induction changes to an appreciable extent from the value at normal load, and any change in the magnetizing current at large overloads affects the result but slightly. At partial loads where the magnetizing current affects the result appreciably, the magnetic induction in the iron is nearly constant. In this hypothetical case where a secondary current is assumed for the purpose of making a calculation, no error is introduced by assuming the magnetizing current to vary in direct ratio with the secondary current, but where the step from a small slip to a much larger slip is made an allowance must be made for the change in magnetizing current with change of induction. The triangle shown in Fig. 2 increases and decreases with the secondary current. The voltage induced in the primary depends on the strength of the field and varies with the secondary current. Also, the primary current and the voltage drop in the primary varies in this ratio.

Since the angles shown in the irregular figure represented by Fig. 3 remain the same for all values of the secondary current and the sides of this figure may be drawn to any scale without affecting the values of the voltage in relation to each other, we can find what will be the different voltages and currents throughout the motor by increasing all of these quantities in direct ratio with the increase in actual impressed voltage over that found for the assumed secondary current. It was found that 520 amperes secondary current require an impressed voltage of 260 volts. An impressed voltage of 283 volts will give

$\frac{283}{260}$ x 520 amperes=566 amperes.

Part of the impressed voltage overcomes the iron loss of the primary. By calculating the induction densities in the different parts of the primary and referring to curves made from tests on the iron used, the watts lost due to hysteresis is found to be 45 watts for the total primary core. The iron loss in the secondary is so small due to the low frequency of alternation of the secondary current that it may be neglected. Each leg of the primary supplies *one-third* of the total power and losses in the motor. No confusion will arise from the fact that it is customary to reduce the line current and voltage to the value per leg for finding the watts per leg, if it be remembered that the law of conservation of energy holds for motors, as well as for any other machine, and that the three legs are symmetrical. In order to show that the power per leg is one-third of the total power, reduce the current single phase to that of a three-phase system, this is $\frac{1}{\sqrt{3}}$ of the single phase value; now the voltage per leg of a star-connected winding is $\frac{1}{\sqrt{3}}$ of that across phase wires, giving a total reduction of ⅓, which is the same as taking one-third the total power for the power per leg.

The 45 watts iron loss is found from effective densities of magnetic induction. Maximum and effective values of power do not have the same relation as maximum and effective values of current and voltage, as may be seen by trial. The effective value of current is 70.7 per cent. of its maximum value and the effective value of voltage is 70.7 per cent. of its maximum. Power, that is, watts, are obtained by multiplying current by voltage and, if this is done, the effective power is found to be 50 per cent. of maximum power.

Dividing the 45 watts iron loss by three and multiplying this result by two gives 30 watts as the maximum iron loss per leg. The primary current with 260 volts per leg was found to be 40.8 amperes and with 283 volts it would be

$\frac{283}{260}$ x 40.8=44.5 amperes.

The iron loss is the product of the primary current by the volts drop due to this loss and the volts drop can be found by dividing the watts loss by the current

$\frac{30 \text{ watts}}{44.5 \text{ amperes}}$ =.675 volts.

This voltage should be added to the resistance drop in Fig. 3 and increases the impressed voltage from 260 volts to 260.68 volts, a difference which may be neglected at 7.5 per cent. slip, but which should be taken into account at very small slips.

The secondary current has been found to be 556 amperes with 283 volts per leg. This amounts to 400 amperes effective. The resistance of each bar of this motor secondary multiplied by the number of bars is .00381 ohms. The current in each bar attains a maximum when the rotating field is producing its maximum effect, and changes when the relative positions of bar and rotating field change. All the bars are subjected to the same influence of this field and the effective current derived from the maximum current in any bar is the effective current in all the bars. The ohmic loss in the bars is then

400^2 x .00381 ohms=610 watts.

The maximum current in the end rings is 4.3 times the maximum current in one bar. Since rings and bars are acted on uniformly, the effective current around both end rings is derived from the maximum current in any portion of either end ring at any time, and the effective current in both end rings is 4.3 times the effective current in the bars, amounting to 1720 amperes. The total resistance of these two end rings is .000211 ohms, giving

1720^2 x .000211=625 watts.

The total watts generated in the

secondary and lost in heating the secondary winding is 1235 watts at 7.5 per cent. slip. The power required to hold the secondary at 7.5 per cent. slip by means of a brake or by a driven machine is equal to the resistance loss multiplied by $\frac{1-\text{slip}}{\text{slip}}$

With the loss found above the power developed at 7.5 per cent. slip is $1235 \times \frac{1-.075}{.075} = 15{,}200$ watts.

This is the equivalent of 20.4 horse-power. A motor with the constants

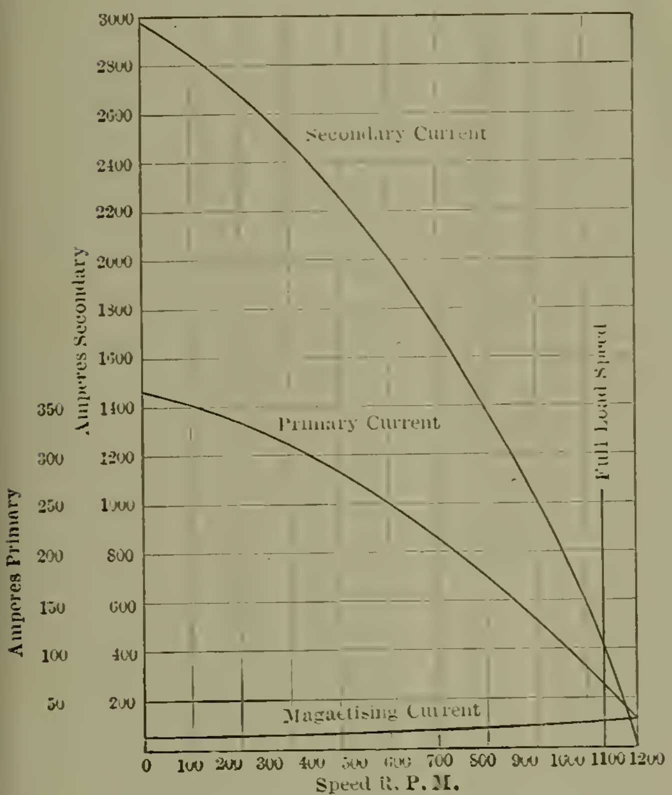


FIG. 4.

as given will develop 20 horse-power at 7.5 per cent. slip and will have amply sufficient reserve power to overcome friction and windage.

If the synchronous speed of this motor be 1200 r. p. m., the speed at 7.5 per cent. slip will be 1110 r. p. m., and the torque 95 pounds on a pulley one foot radius.

The efficiency of the motor is found by adding the primary and secondary c^2r loss to the watts loss for the hysteresis of the iron and to the motor output and dividing this sum into the output, care being taken to use effective values of current and to in-

I have made the above calculations for a number of slips and find the values as plotted in the curves, Figs. 4 and 5. Current values are represented in Fig. 4. It will be seen that this motor differs considerably from the older types of induction motors. The primary current continually include the losses in all three legs of the primary.

The power factor of the motor is the cosine of the angle between resistance volts and impressed voltage as given in Fig. 3.
creases with reduced speed, reaching a value of seven times normal full load current when the speed is reduced to zero. It is evident that some form of starting device should be used for starting a motor of this type and the motor mains should be protected by fuses or circuit breakers.

The current values as found in the calculations are current per leg of the motor winding, and since the motor is delta connected, the current per line wire will be $\sqrt{3}$ times the current per leg. The current in the line is the value represented by Fig. 4.

The primary current reduces to about 25 amperes at synchronous speed and the magnetizing current reaches nearly this amount at this speed. There is a slight difference between the true magnetizing current and the apparent value used for calculation due to the hysteresis of the iron. I have allowed for this difference when plotting the curve.

The secondary reactance increases with reduced speed, causing the bending over of primary and secondary current curves. This droop does not compare with that of motors having a large secondary reactance.

One of the chief characteristics of this motor is the torque curve. By inspecting the torque curve the torque will be found to increase with reduced speeds to about 80 per cent. slip, from which speed to standstill the

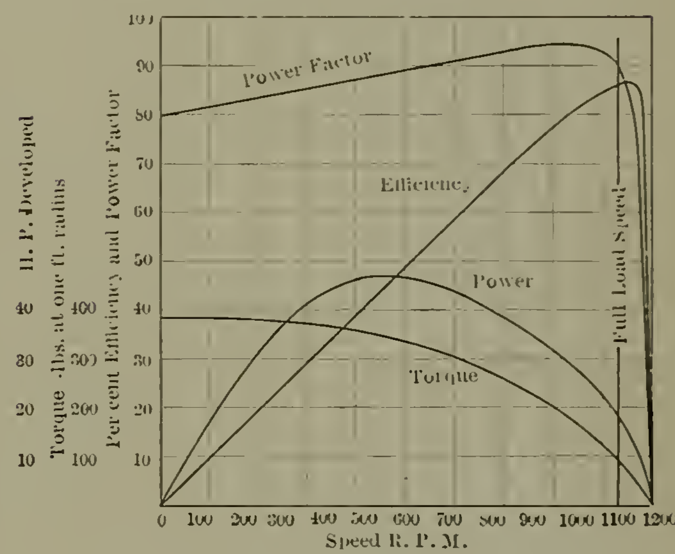


FIG. 5.

torque is practically constant; that is, this motor cannot be stalled by an overload. It has no pull-out point. The torque characteristic is similar to that of a variable-speed motor, in that the greatest torque is obtained at starting, while the large increase of torque with reduction of speed at normal load makes this an excellent constant-speed motor.

The power factor is also high at low speeds, and a motor with these characteristics will affect the line voltage but slightly, whether starting or running.

Electric Motor Connections

Compound-Wound Motors

NORMAN G. MEADE

THE compound-wound motor has a combination of both shunt and series windings, and if the currents flows in the same direction in both, the effect of the series coils is to strengthen the field formed by the shunt winding. This strengthening varies with the load, being the greatest when the motor is operating at maximum load.

It follows, then, that for a given current the starting torque of a compound-wound motor will be greater than that of a shunt-wound motor. The compound-wound motor has therefore some of the characteristics of a series motor without the attendant disadvantage of "running away," which occurs with the latter machine when the load is suddenly thrown off, as the shunt coils produce a magnetic field of sufficient strength to prevent any abnormal variations in the speed of the motor.

The compound-wound motor is particularly adapted to the operation of planers, shapers, slotters and all machines with reciprocating motions, where excessive power is required during reversal of stroke, as the increase of field strength with increase of current tends to maintain a more uniform field, lessening the effects of armature reaction, thereby maintaining good commutation over a wide range of loads.

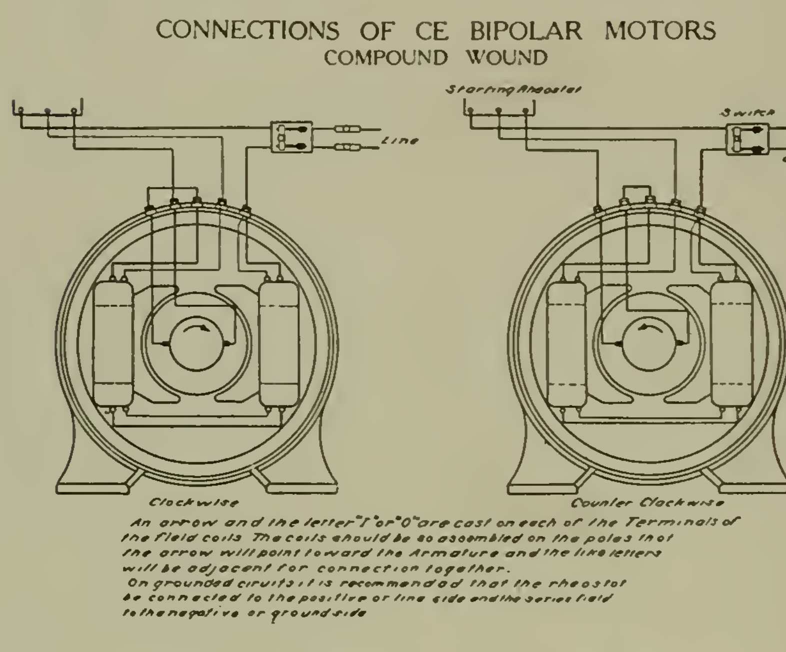


FIG. 70.—GENERAL ELECTRIC COMPANY.

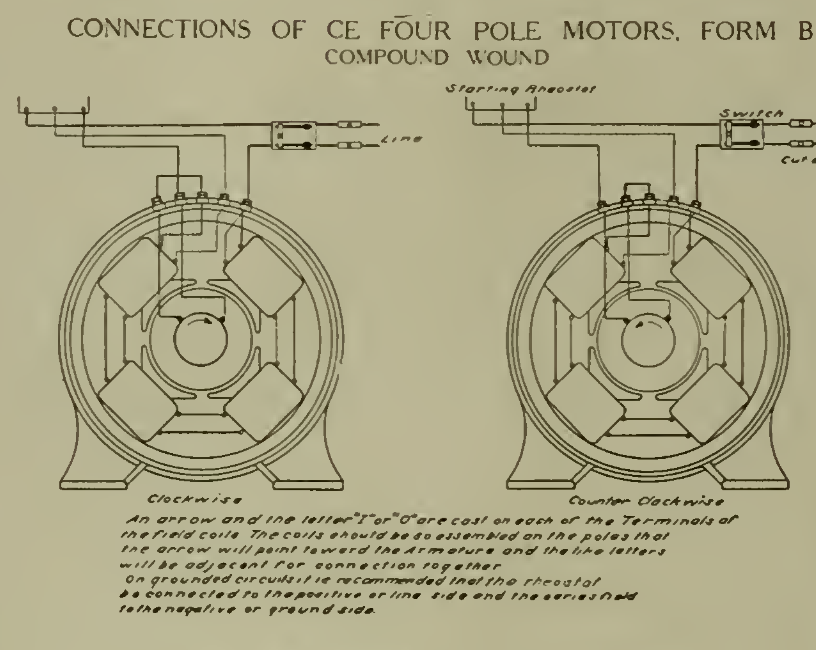


FIG. 72.—GENERAL ELECTRIC COMPANY.

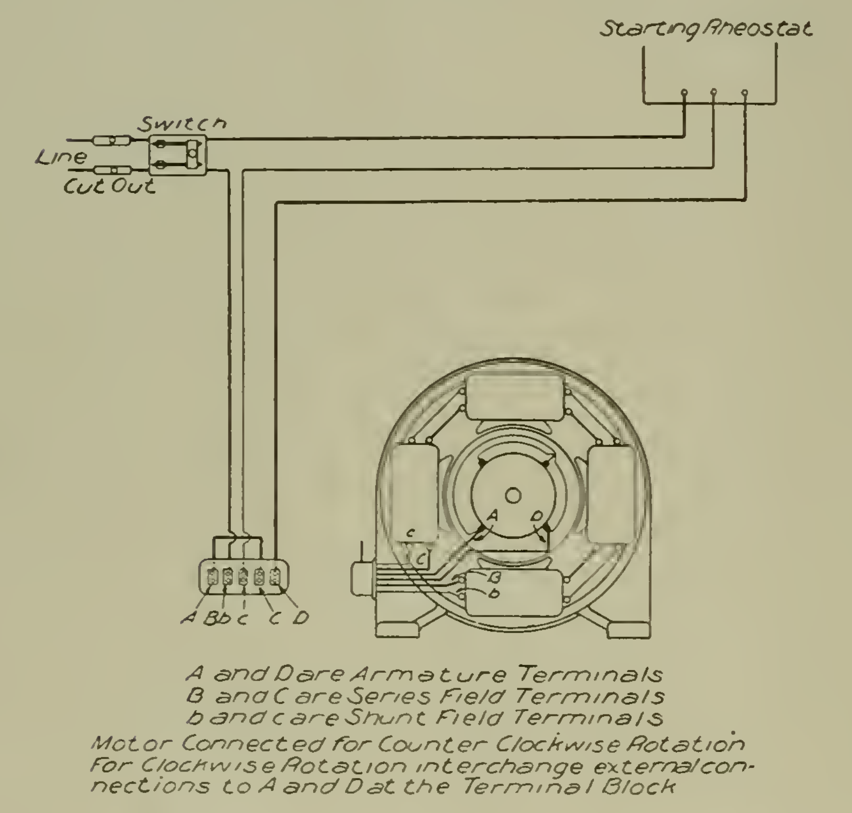


FIG. 71.—GENERAL ELECTRIC COMPANY, C. Q., FOUR-POLE MOTORS.

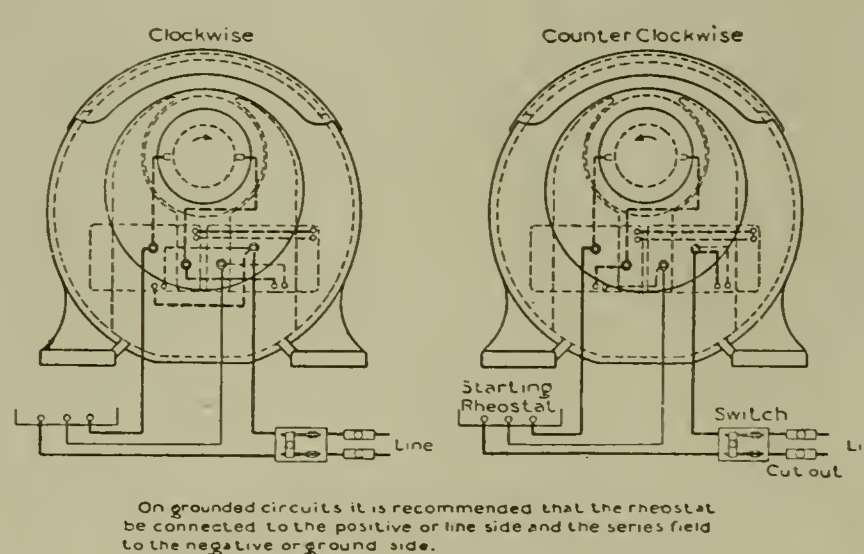
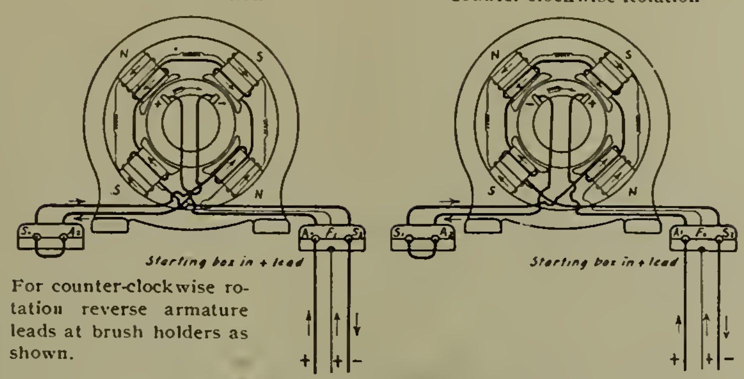
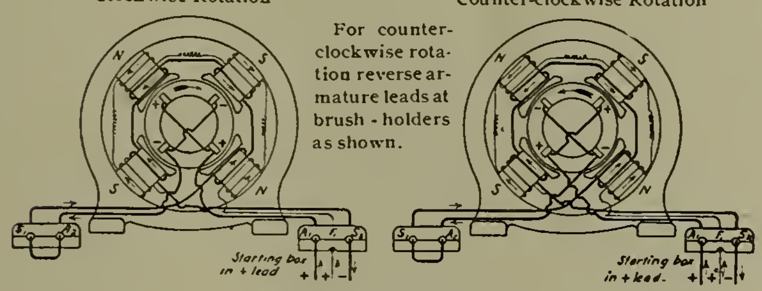


FIG. 73.—GENERAL ELECTRIC COMPANY, C. A., BIPOLAR MOTORS, FORM B.

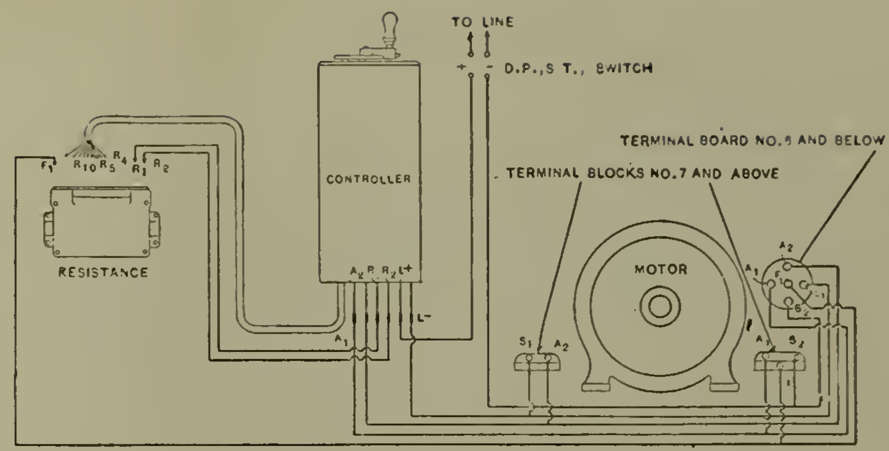


Type S Compound Wound Motors—Frames 7 to 13 Inclusive—Four Brush Arms Seen From Commutator End



Type S Compound Wound Motors—Frames 7 to 13 Inclusive—Two Brush Arms Seen From Commutator End

FIG. 74.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.



CONNECTIONS FOR COMPOUND WOUND MOTOR, TYPE S.

FIG. 77.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

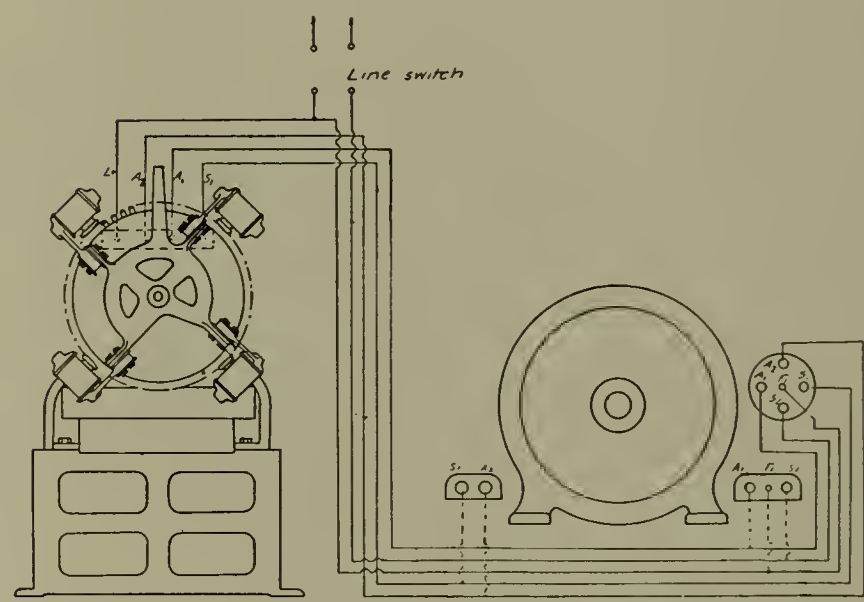


Diagram of Connections of Compound Wound Type S Motors and Type 179 Controller, 10 to 30 h.p. at 110 Volts and 10 to 75 h.p. at 220 Volts For Frames 1 to 6 Inclusive. Connect as Shown by Full Lines. For Frames 7 and above. Connect as Shown by Dotted Lines

FIG. 78.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

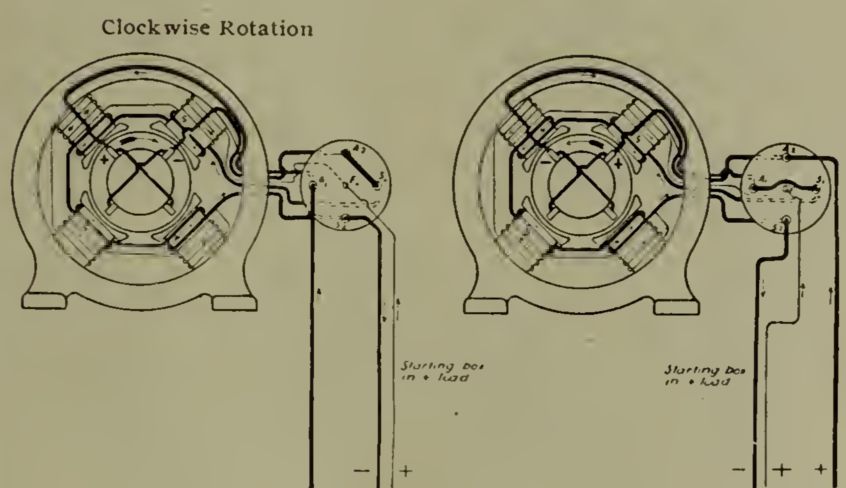


FIG. 75.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, TYPE "S" MOTOR, FRAMES 1 TO 6, INCLUSIVE, TWO OR FOUR BRUSH ARMS.

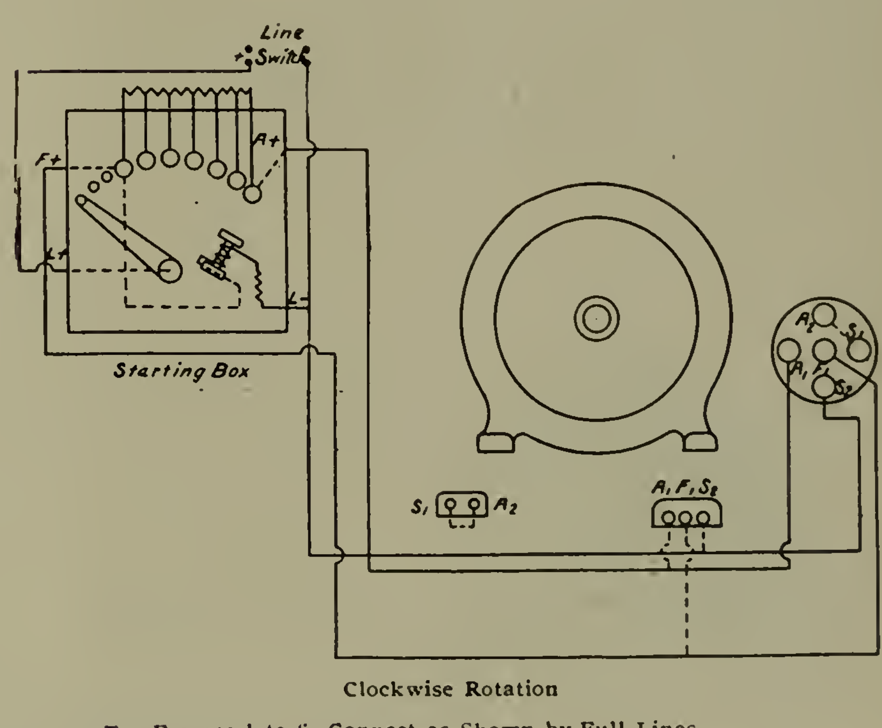


FIG. 79.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, STARTING RHEOSTAT FOR TYPE "S" CONSTANT SPEED MOTORS.

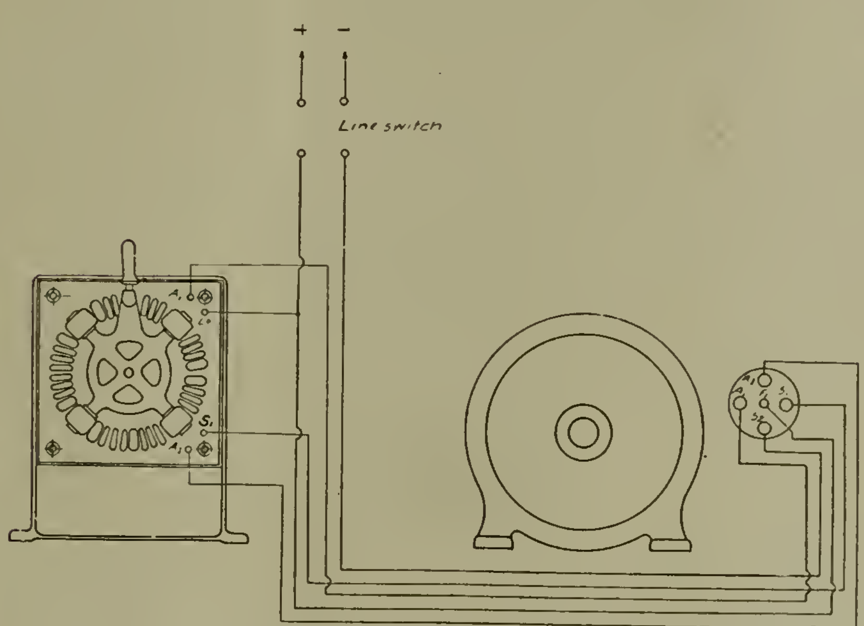
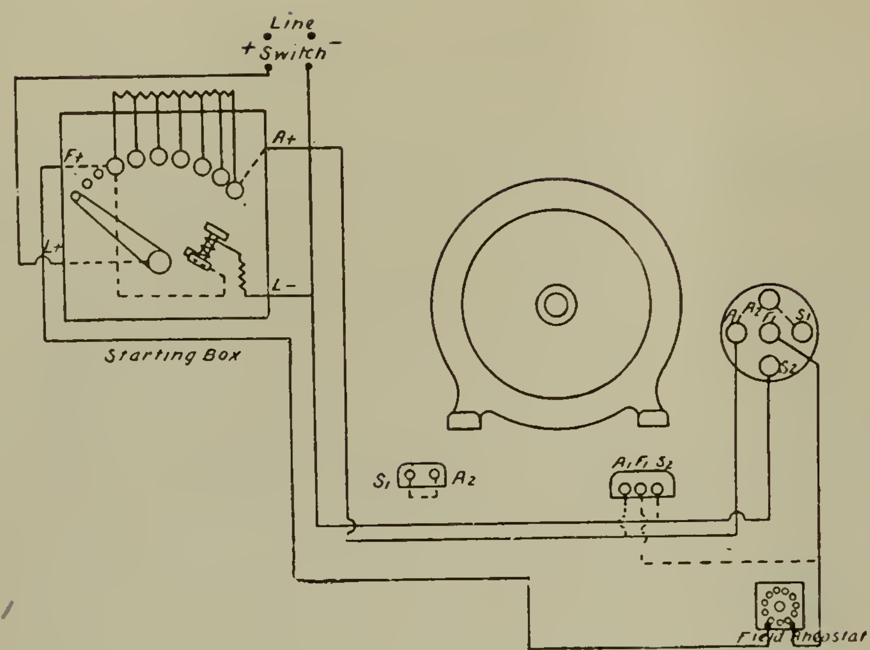


Diagram of Connections of Compound Wound Type S Motors and Type 177 Controller, 2 to 10 h.p. For Frames 1 to 6 Inclusive

FIG. 76.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY



For Frames 1 to 6—Connect as shown by Full Lines.
For Frames 7 and above—Connect as shown by Dotted Lines.

FIG. 80.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, STARTING RHEOSTAT AND FIELD RHEOSTAT FOR TYPE "S" MOTOR, CLOCKWISE ROTATION.

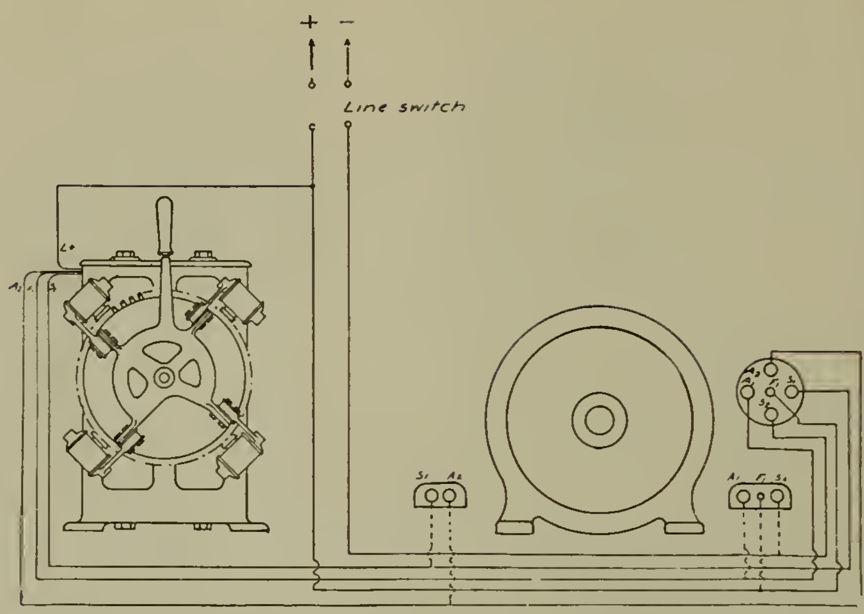


Diagram of Connections of Compound Wound Type S Motors and Type 178 Controller 10 to 30 h.p. at 110 volts and 10 to 75 h.p. at 220 volts

For Frames 1 to 6 Inclusive—Connect as Shown by Full Lines
For Frames 7 and above—Connect as Shown by Dotted Lines

FIG. 83.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

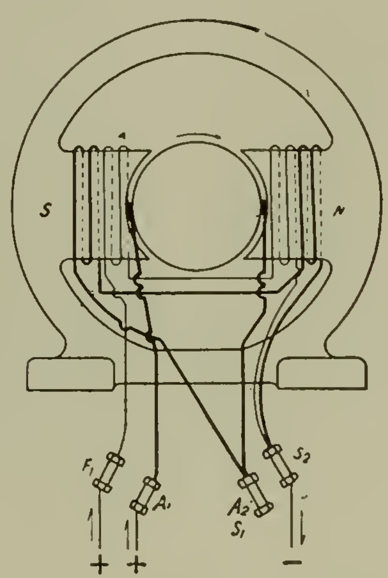
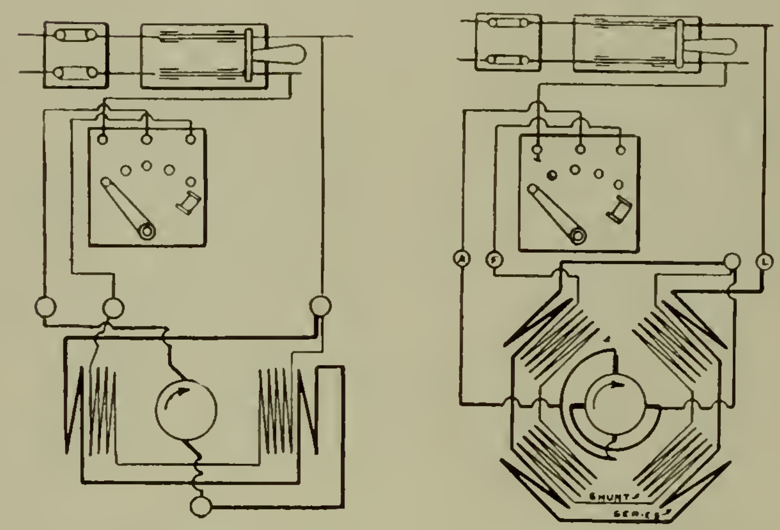


FIG. 81.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY BIPOLAR MOTOR.



CONNECTION DIAGRAM 2 POLE COMPOUND MOTOR

CONNECTION DIAGRAM 4 POLE COMPOUND MOTOR

FIG. 84—ROBBINS & MYERS COMPANY.

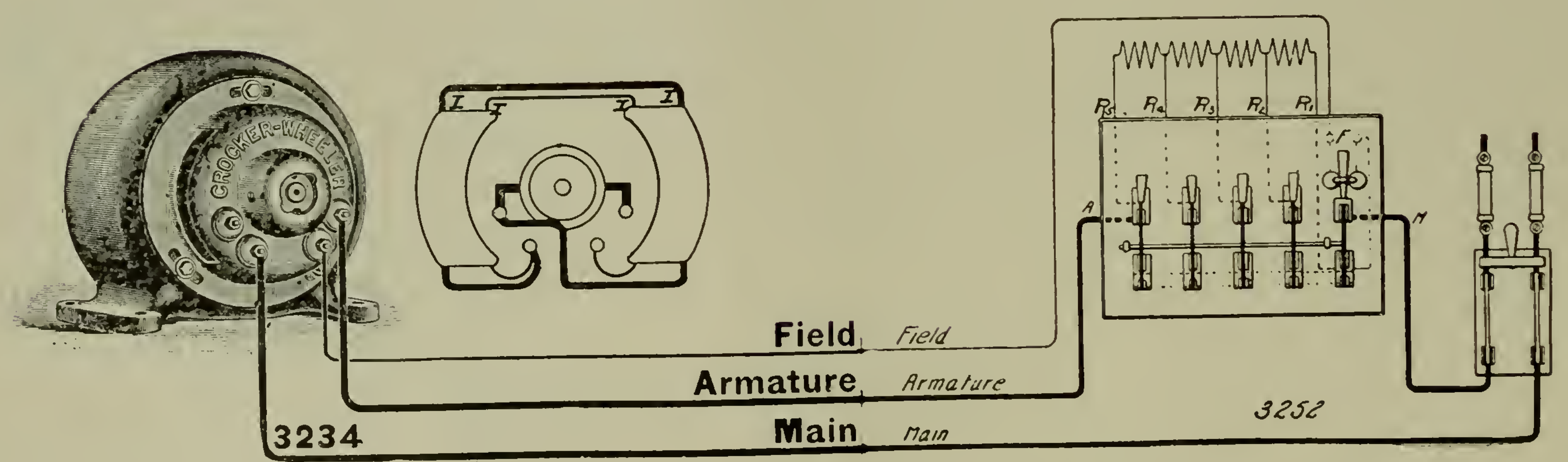
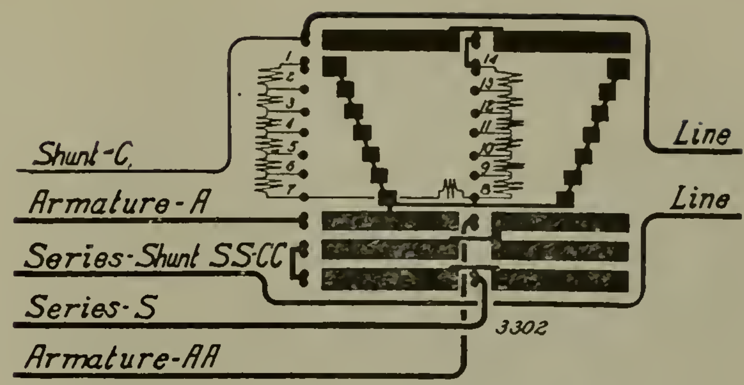


FIG. 82.—CROCKER-WHEELER COMPANY MOTOR, CONNECTED TO BLADE STARTER WITH AUTOMATIC CUT-OFF.



WIRING DIAGRAM
SIZE 44, 84 OR 174 CONTROLLER WITH COMPOUND MOTOR.

FIG. 85.—CROCKER-WHEELER COMPANY.

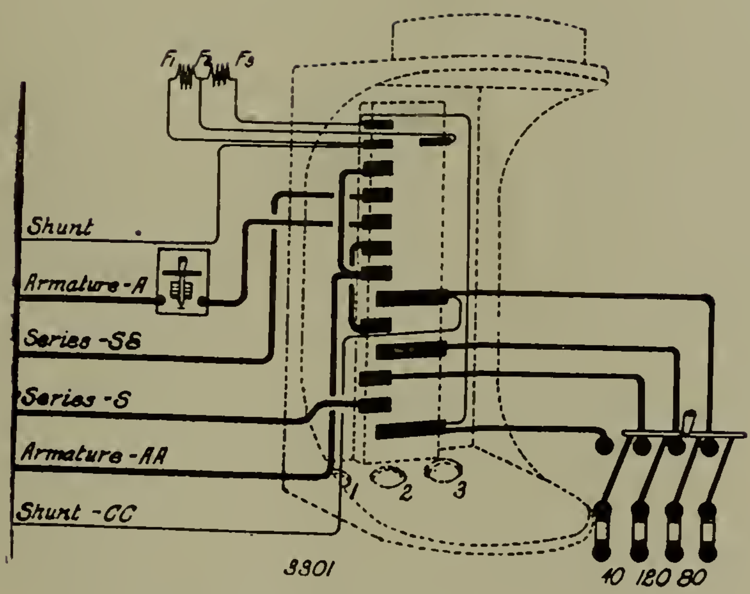
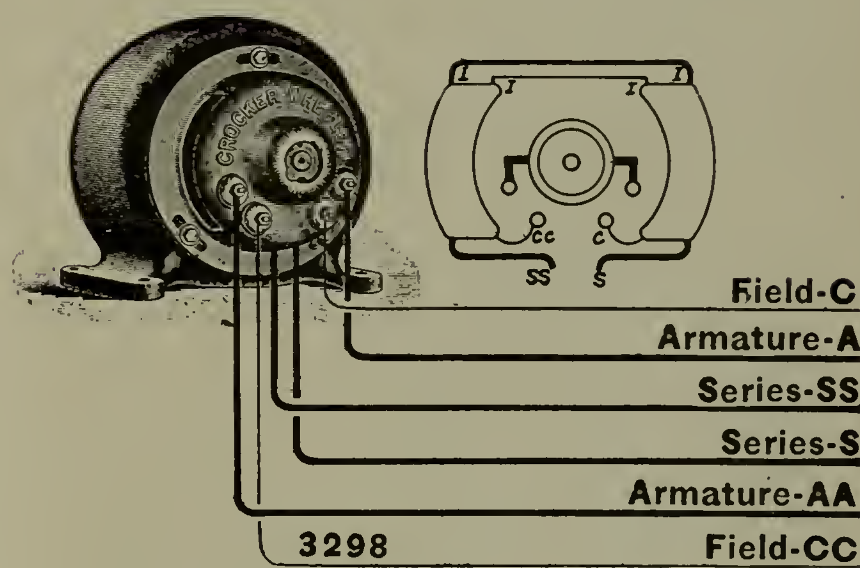
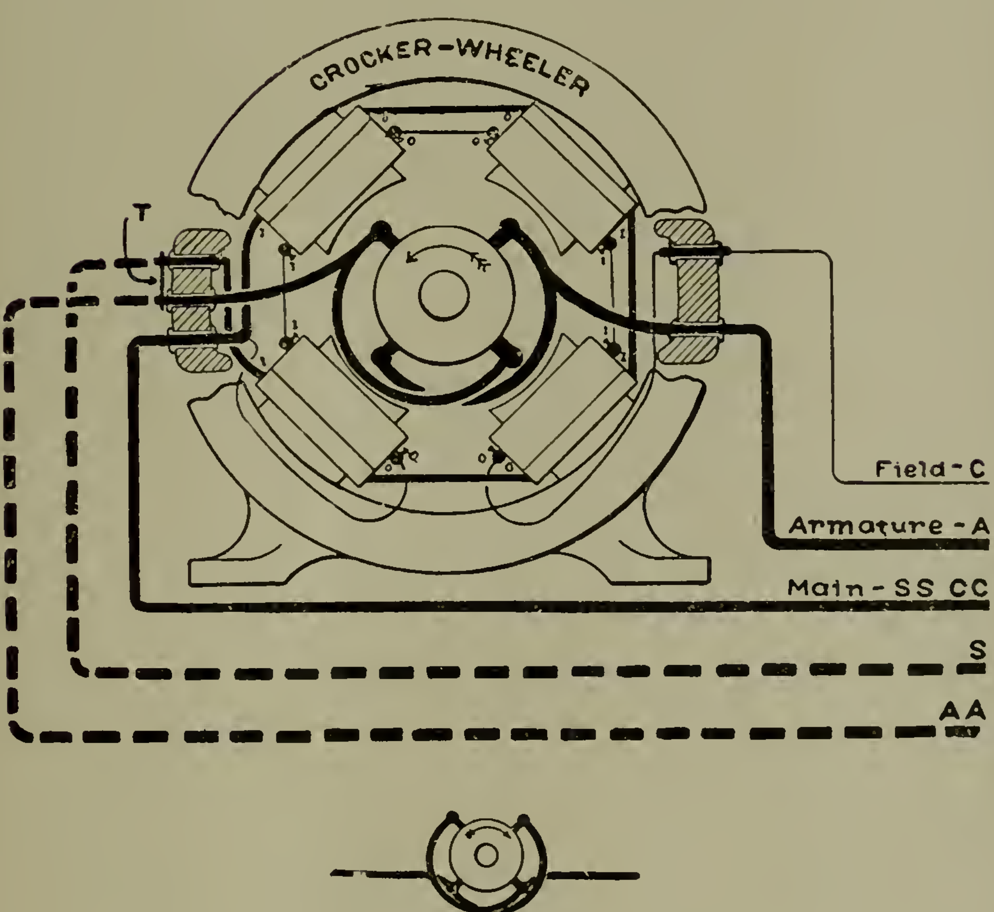


FIG. 83.—CROCKER-WHEELER COMPANY, SIZE 39 M. F., 14 OR 79 M. F., 15 CONTROLLER FOR MULTIPLE VOLTAGE SYSTEM.



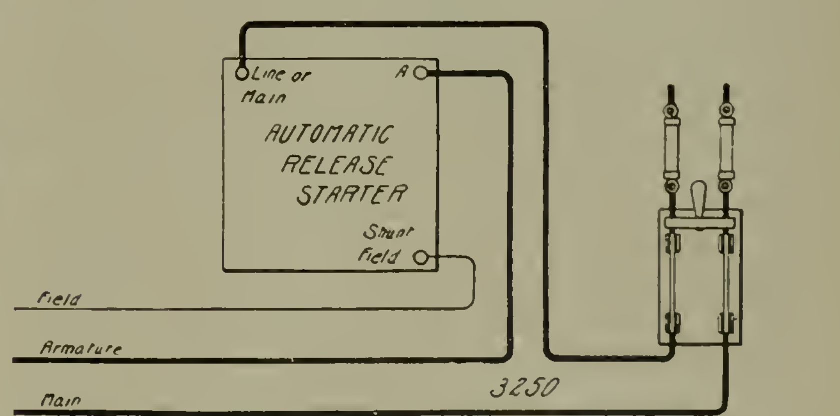
If shunt field is not separately excited "SS" can be connected to "CC" internally and the two external leads "SS" and "CC" can then be combined into one, running from the field terminal "CC."

FIG. 86.—CROCKER-WHEELER COMPANY DIAGRAM FOR REVERSING COMPOUND MOTORS—FORM L, SIZES 1/4 TO 2.



If motor must run in both directions, remove copper connector "T" and use dotted connection also. Set rocker so that motor runs equally well in either direction. To change direction of rotation, connect armature cables to bottom brushes as shown in small cut.

FIG. 84.—CROCKER-WHEELER COMPANY.



SMALL STARTERS WITH AUTOMATIC CUT-OFF FOR SHUNT AND COMPOUND MOTORS

FIG. 87.—CROCKER-WHEELER COMPANY.

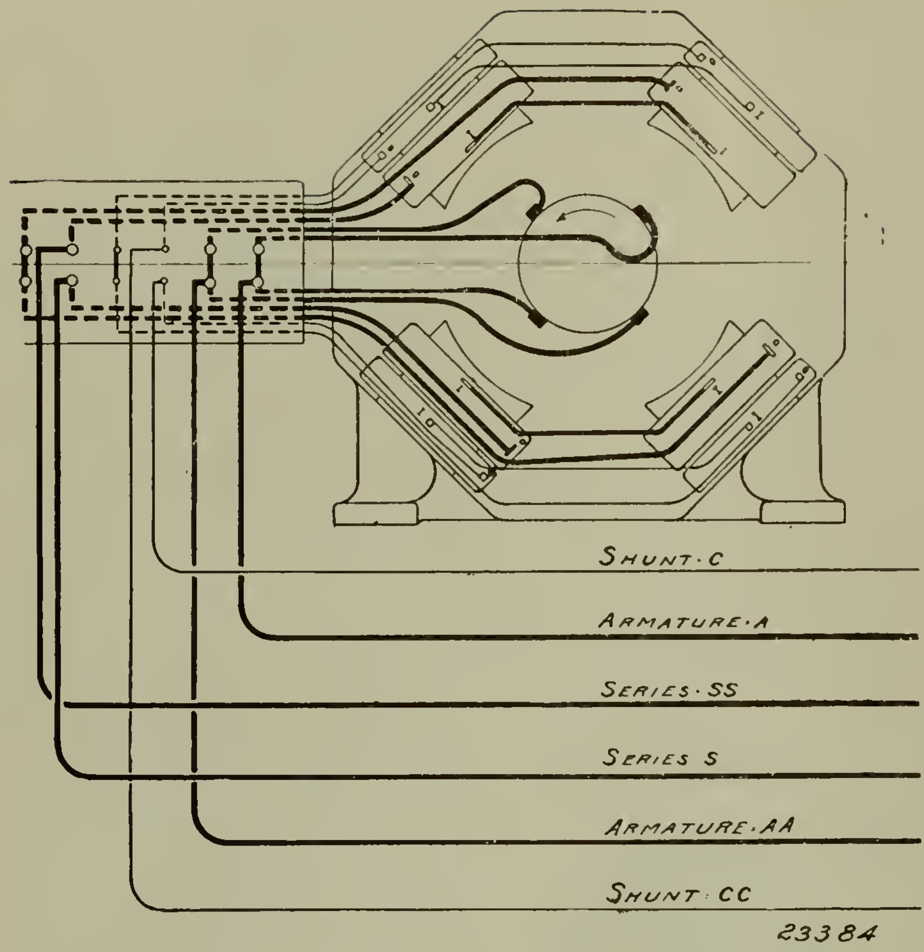


FIG. 88.—CROCKER-WHEELER COMPANY CONNECTION DIAGRAM FOR SIZES 25 W. AND 50 W.

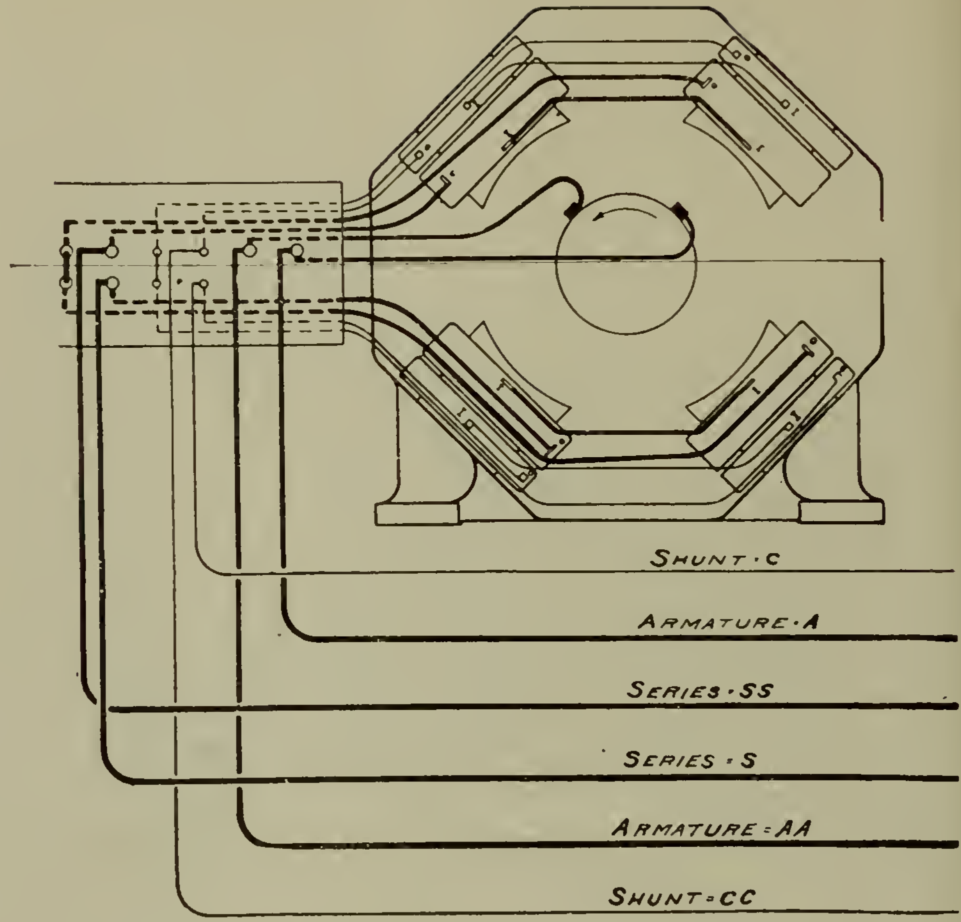


FIG. 91.—CROCKER-WHEELER COMPANY CONNECTION DIAGRAM FOR SIZES 75 W. AND 100 W.

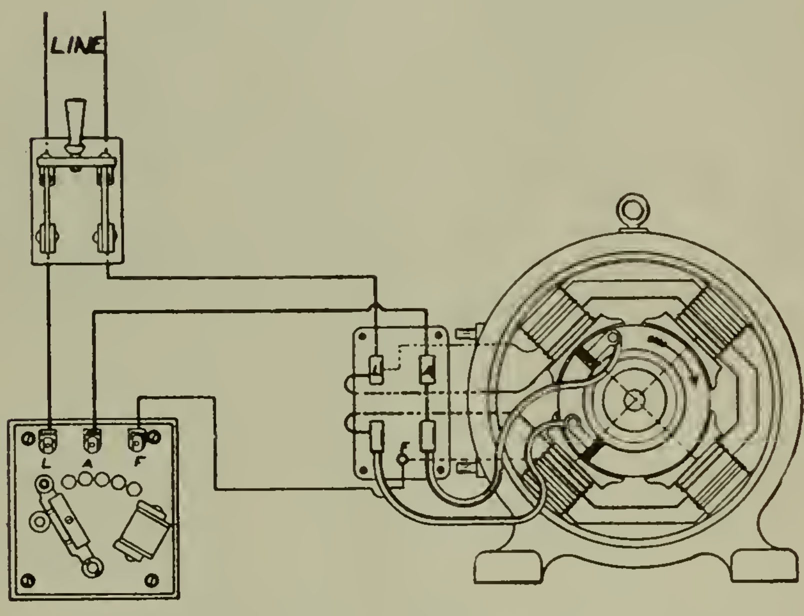


FIG. 89.—HOLTZER CABOT ELECTRIC COMPANY CONNECTIONS FOR 5-H. P. AND OVER. TYPE "E" COMPOUND MOTOR.

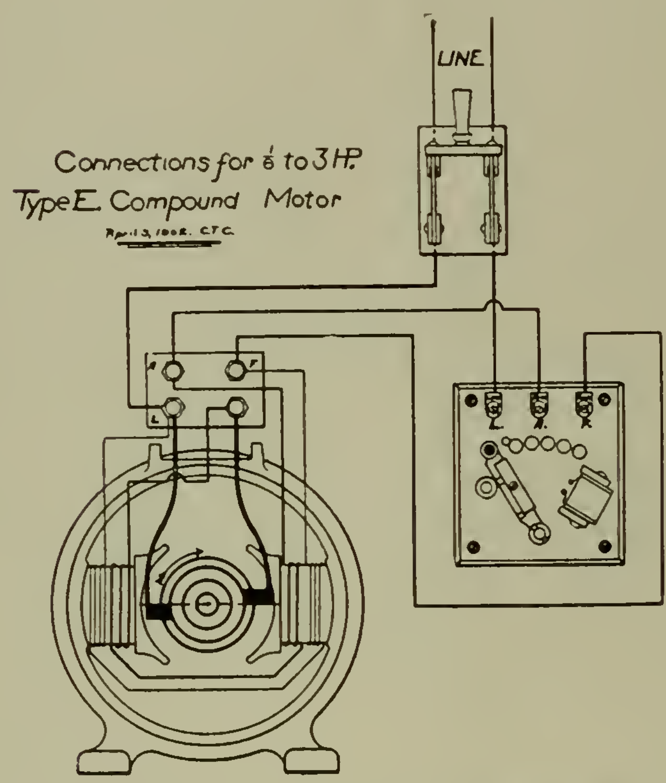


FIG. 92.—HOLTZER CABOT ELECTRIC COMPANY.

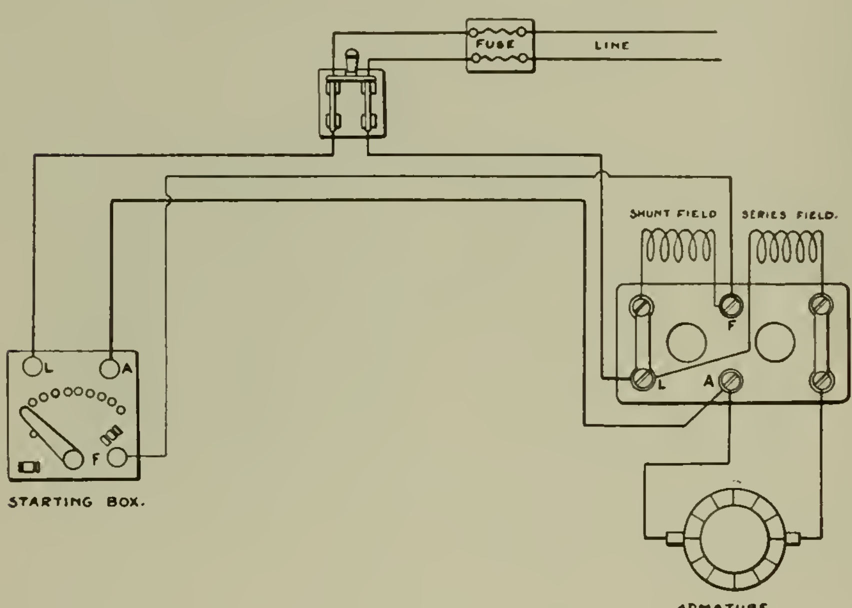


FIG. 90.—SPRAGUE ELECTRIC COMPANY LUNDELL ROUND-TYPE MOTORS, NOS. 4, 5, 7½ AND 10 FRAMES.

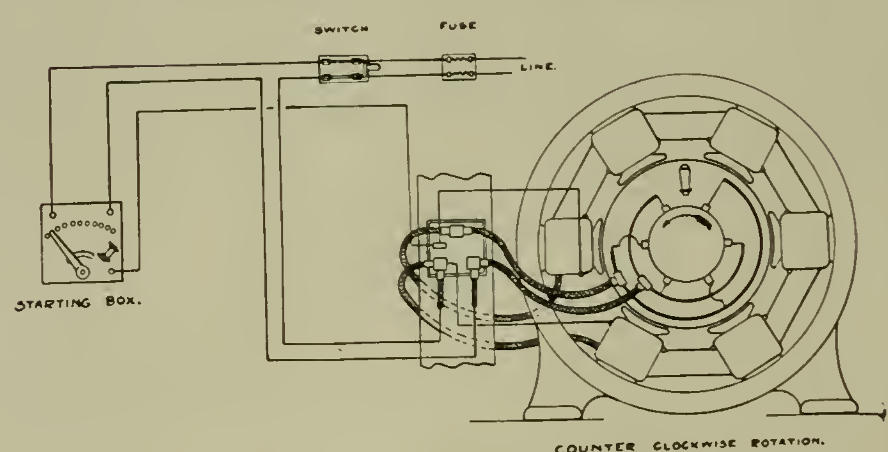


FIG. 93.—SPRAGUE ELECTRIC COMPANY TYPE "D" MOTORS.

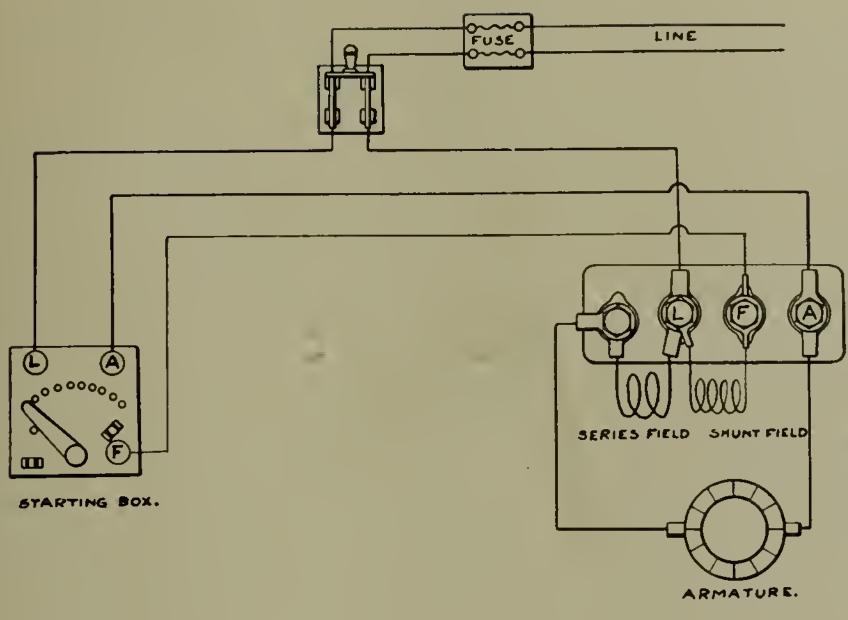


FIG. 94.—HOLTZER CABOT ELECTRIC COMPANY.

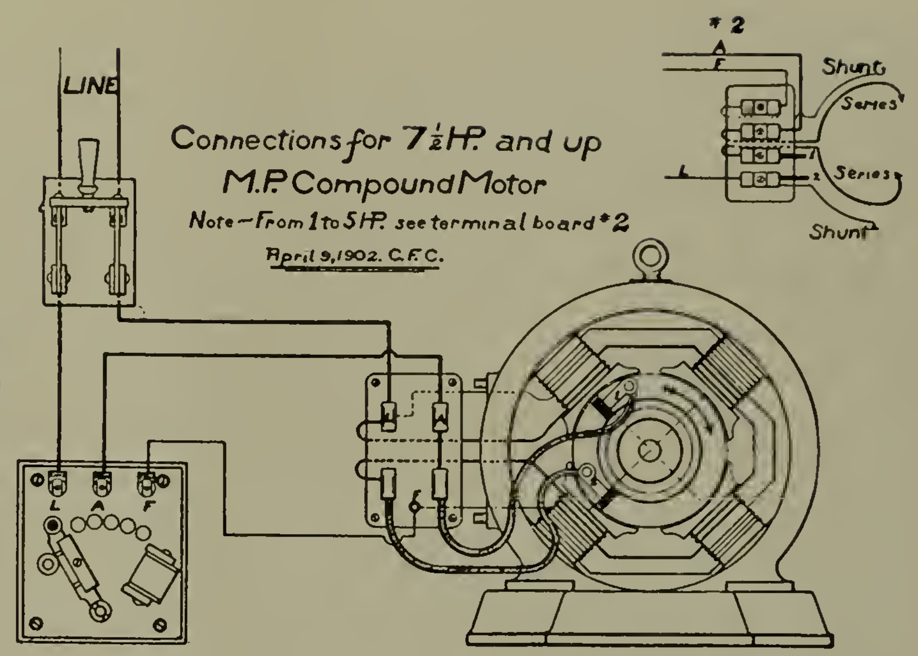


FIG. 95.—SPRAGUE ELECTRIC COMPANY LUNDELL ROUND-TYPE MOTOR FOR ¼, ½, 1, 2 AND 3 FRAMES.

Power-Factor Correction for Synchronous Motors

Alternating - current systems have generally recognized and, in many cases, controlling advantages; they may have, on the other hand, one serious disadvantage not encountered in direct-current systems—that of low power-factor. With the rapid increase in the industrial use of induction motors and in arc lighting by alternating current, the troubles incident to low power-factor, in systems not designed for it, have become unfortunately familiar. In a paper read at the recent convention of the National Electric Light Association, F. D. Newbury pointed out the more important effects of low power-factor and to show how, in some cases, these bad effects may be overcome by the proper application of over-excited synchronous motors.

THE EFFECTS OF LOW POWER-FACTOR.

Low power-factor has two serious results; it limits the capacity of the electrical part of the system by loading it up with unproductive current—current for which no revenue is obtained; and it means poor voltage regulation.

Unproductive Current:

When the power-factor is 100 per cent.—when the current and voltage are in phase—all the current is effective in doing work and the kilowatts, measured by a wattmeter, are the same as the kilovolt-amperes, measured by a voltmeter and ammeter. At power-factors lower than 100 per cent.—when the current is not in phase with the voltage—only that component of the current that is in phase with the voltage is effective in doing work and only this component is measured by the wattmeter. The ammeter, however, measures the total current.

With power-factors lower than 100 per cent. the kilowatts are therefore less than the kilovolt-amperes, the ratio between them being equal to the power-factor. The rating of electrical apparatus depends primarily on the heating produced by the load, and this heating depends entirely on the current. The kilowatt load, therefore, unless the corresponding power-factor is taken into account, is not a measure of the actual load on the apparatus.

This has an important bearing on the relative ratings of prime movers and electrical apparatus. The capacity of prime movers is determined solely by the energy load as measured by the wattmeter. The capacity of electrical apparatus—generators, transformers or feeders—is determined by the kilovolt-ampere load, which, with a given energy load, depends on the power-factor. The power-factor, therefore, should be taken into account in selecting a generator for a given engine. This, unfortunately, is done in very few cases. It is all too common to make the kilovolt-ampere rating of the generator equal to the kilowatt rating of the engine. The current load on the generator will only correspond with the energy load on the engine when the kilovolt-amperes equal the kilowatts, which is at 100 per cent. power-factor. At lower power-factors, the generator will be carrying more load, relatively to its rating, than the engine.

It is putting the matter very conservatively when it is stated that in less than half the power plants designed, has the power-factor been taken into account, as it should be, in determining the relative ratings of the engine and generator. This means that in a large number of plants it is only the large overload capacity of the generators that enables them to put even full load on the engines.

This unequal loading of the engines and generators is not the only bad condition due to this effect of low power-factor. The revenue of a station is affected. The revenue depends on the kilowatt load and not on the kilovolt-ampere load, since power taken by customers is measured by wattmeter. Therefore, with low power-factor the generators, transformers and feeders are loaded up with current that can bring in no revenue. In a system in which the engines have a kilowatt rating equal to the kilovolt-ampere rating of the generators and other electrical apparatus, the revenue-producing capacity of the system is cut down in direct proportion to the power-factor. At 70 per cent. power-factor, for example, the revenue will be only 70 per cent. of the revenue that could be obtained at 100 per cent. power-factor from the same current and same investment in electrical apparatus.

Low power-factor, then, means that unless the system has been consistently designed for the power-factor at which it is operating, the different parts of the system are unequally loaded. If the engines are underloaded the possible revenue is curtailed; if the engines are carrying their rated load the electrical part of the system is overloaded, with attendant troubles and poor service to the customers.

Voltage Regulation:

The second injurious effect of low power-factor is poor voltage regulation. This effect is well known and requires no extended explanation. It will suffice, in the present paper, to show how large this effect may be, considering in turn each part of the electrical system.

Considering first, the generators—it has been the general practice up to this time to design generators for an inherent regulation of approximately 8 per cent. at their rated load and 100 per cent. power-factor. There is, however, a tendency toward higher regulation percentages, particularly in large units, since a considerable reduction in cost can be made without any corresponding sacrifice in practical operating performance. However, with a generator having 8 per cent. regulation at 100 per cent. power-factor, with the same current and 80 per cent. power-factor the regulation, in the majority of cases, will be between 20 per cent. and 25 per cent., varying in different generators on account of more or less magnetic saturation.

It is worth while noting that the more saturated a generator is, the better regulation it will have, particularly at low power-factors; so that, while apparently the saturated generator is the better unit on account of the better regulation, it is, in fact, the poorer unit, since it will not hold up its voltage under heavy loads so well as the more nearly unsaturated generator. This will be referred to later.

At the same kilowatt load and 80 per cent. power-factor (which means 25 per cent. overload in current) the regulation will be between 25 per cent. and 30 per cent. The importance of inherent regulation of generators from an operating standpoint is minimized by the ease with which the excitation can be increased and thus compensate for the drop in voltage. This is particularly true provided an automatic voltage regulator is installed. Similar compensation in transformers or feeders requires relatively expensive auxiliary apparatus.

In transformers of 60 cycles and in fairly large units—say between 200 k.w. and 1000 k.w.—the regulation at 100 per cent. power-factor and normal rated current will be between 1.6 per cent. and 0.8 per cent. With the same current and 80 per cent. power-factor the regulation will be between 4 per cent. and 2.5 per cent. At 25 per cent. overload in current and 80 per cent. power-factor, which is equivalent to normal load in kilowatts and 80 per cent. power-factor, the regulation will be between 5 per cent. and 3 per cent.

In small lighting transformers—up to 50-k.w. capacity—the regulation will be poorer than in the larger transformers at 100 per cent. power-factor and very nearly the same at 80 per cent. power-factor. At 100 per cent. power-factor the regulation of small transformers will lie between 2.7 per cent. and 1.3 per cent. At normal rated current and 80 per cent. power-factor the regulation will lie between 3.9 per cent. and 2.5 per cent., and at 25 per cent. current overload and 80 per cent. power-factor the regulation will lie between 5 and 3 per cent.

The regulation of feeders is similarly affected by low power-factor, but the magnitude of the effect varies widely on account of the varying ratio between the resistance and reactance drops in different cases. With equal resistance and reactance drops and a total drop of 10 per cent. at 100 per cent. power-factor, the drop at the same current and 80 per cent. power-factor will be 13.5 per cent. and the drop at the same kilowatts and 80 per cent. cent. power-factor will be 16.5 per cent. With a reactance drop double the resistance drop and a total drop of 10 per cent. at 100 per cent. power-factor, the drop at the same current and 80 per cent. power-factor will be 17 per cent. and the drop at the same kilowatts and 80 per cent. power-factor will be 23 per cent. With 60 cycles and a spacing of about twelve inches between wires, the reactrance and resistance become equal with about No. 0 B. and S. gauge conductors. For larger conductors the reactance is greater and for smaller conductors the resistance is greater.

These various figures, showing the magniture of the effect of power-factor on regulation, are summarized in the following table:

While these figures are necessarily approximate, they at least indicate the importance of power-factor in maintaining good service.

It has been previously pointed out that the importance of inherent regulation of generators is minimized by the ease with which drop in generator voltage can be compensated for by increasing the field current. This is only true provided the field current can be sufficiently increased with the available exciting voltage. In any generator there is a maximum field current that can be obtained, determined by the resistance of the field winding and the available exciting voltage. If the load and power-factor require a field current in excess of this maximum, it is obvious that the voltage will fall in spite of anything the station operators can do. The field current required depends somewhat on the current load but largely on the power-factor. Unless a generator has been designed to carry loads of low power-factor the maximum field current obtainable will be insufficient to maintain the normal voltage under this load condition. If a generator has a saturated magnetic circuit the increase in field current required for loads of low power-factor is much greater than if there were less saturation. For this reason an unsaturated generator will give better operating performance, because it can carry heavier inductive loads, even though the percentage regulation would be lower than in a similar generator with more saturation. With a generator not suited for loads of low power-factor, either by reason of insufficient field current or saturation, it is possible, then, to have a serious drop in voltage in the generator, due to low power-factor.

A caution is needed, in considering the bad effects of low power-factor, against concluding that a high power-factor is always better than a low power-factor without considering the means by which the higher power-factor is obtained. The power-factor may be raised by decreasing the inductive load or by increasing the energy load. High power-factor obtained by decreasing the inductive load will always

	Regulation.				
	Of Generators	Of Large Transformers 200-Kw. to 1000-Kw.	Of Lines and Feeders: Equal Reactance and Resistance	Of Lines and Feeders: Reactance Double Resistance	Of Small Lighting Transformers up to 50-Kw.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
At normal rated load and 100 per cent. power-factor	8.0	1.6 to 0.8	10.0	10.0	2.7 to 1.3
At same current and 80 per cent. power-factor	20 to 25	4.0 to 2.5	13.5	17.0	3.9 to 2.5
At same kilowatt and 80 per cent. power-factor	25 to 30	5.0 to 3.0	16.5	23.0	5.0 to 3.0

mean a gain; high power-factor obtained by increasing the energy load will only mean a gain provided the increase in energy load is accompanied by a corresponding increase in revenue. An increase in power-factor obtained by increasing the energy load by increasing the losses in the system simply means an increased load on the entire system with no compensating advantage.

APPLICATION OF SYNCHRONOUS MOTORS TO POWER-FACTOR CORRECTION.

Enough has been presented to show the desirability of operating a system at high power-factor. But many classes of load, particularly constant-current transformers for series arc lamps and small induction motors, particularly when underloaded, have inherently a low power-factor, on account of their inductive effect, due mainly to magnetizing current; and with such loads, high power-factor can only be obtained by adding to the system an additional source of magnetizing current that will supply magnetizing current to the inductive apparatus.

The synchronous motor presents a practical means for raising the power-factor in this way. That central-station managers recognize the value of the synchronous motors in this field is shown by the increasing use of synchronous motors in motor-generator sets, in industrial applications that require large units, and, in particular cases, by their use running without energy load, and entirely for their corrective effect, as synchronous condensers.

Where there is a suitable load for a synchronous motor there is now very little question regarding the advisability of its installation in cases where improvement in power-factor is a consideration. The similar use of over-excited synchronous motors, running without load as synchronous condensers, is not so generally recognized as justifiable. The expense connected with their installation is easily seen, while the benefits to be derived are not so obvious.

There are three cases, however, in which the use of synchronous condensers can be shown to be good practice:

1. In existing systems that are up against trouble due to low power-factor, which can be remedied only by the installation of synchronous condensers. This is, obviously, no case for argument. This is, undoubtedly, the first field the synchronous condenser will occupy, and, in fact, the synchronous condenser is already in the field—two large installations, at least, being under construction.

2. In proposed systems which will have a large inductive load and in which the investment for feeders and transforming apparatus will be a large proportion of the total cost.

3. In proposed systems which will have a large inductive load and in which slow-speed generating units—such as gas-driven units—will be used.

The field of application of the synchronous condenser will be largely confined to these three cases. Under all other conditions the additional capacity made necessary by low power-factor can be most economically provided by increasing the size of the main generators and other electrical apparatus, so that the entire system, engines, generators, transformers and feeders, will be proportionately loaded at the power-factor at which the system will operate.

Before it can be shown why the use of synchronous condensers is justifiable under the above conditions, it will be necessary to review the principles involved in the operation and application of over-excited synchronous motors.

The action of the over-excited synchronous motor in raising the power-factor of a circuit may be looked at from two points of view. It may be considered that the over-excited synchronous motor furnishes directly the magnetizing current required by the inductive load. For example, referring to Fig. 1, and assuming the synchronous condenser not connected to the circuit, the magnetizing current required by the inductive load must be supplied by the main generator, and all the line between the generator and the inductive load, as well as the generator itself, will be loaded up with this magnetizing or wattless current. Now, assume that the synchronous condenser is in proper operation. Then this magnetizing current is furnished by the synchronous condenser and only that part of the circuit, in addition to the synchronous condenser, between it and the inductive load carries the magnetizing current; and, provided the synchronous condenser is located near the inductive load, practically all the circuit, as well as the generator, is relieved of the wattless current. An important point is clearly brought out by this illustration. Adding the synchronous condenser to the system does not eliminate the magnetizing current entirely from the circuit. It is simply transferred from the generator to the synchronous condenser. As long as an inductive load is connected to the circuit its wattless current must be supplied from some source in the circuit. Whether it can be most economically supplied by the main generator or by an auxiliary source of magnetizing

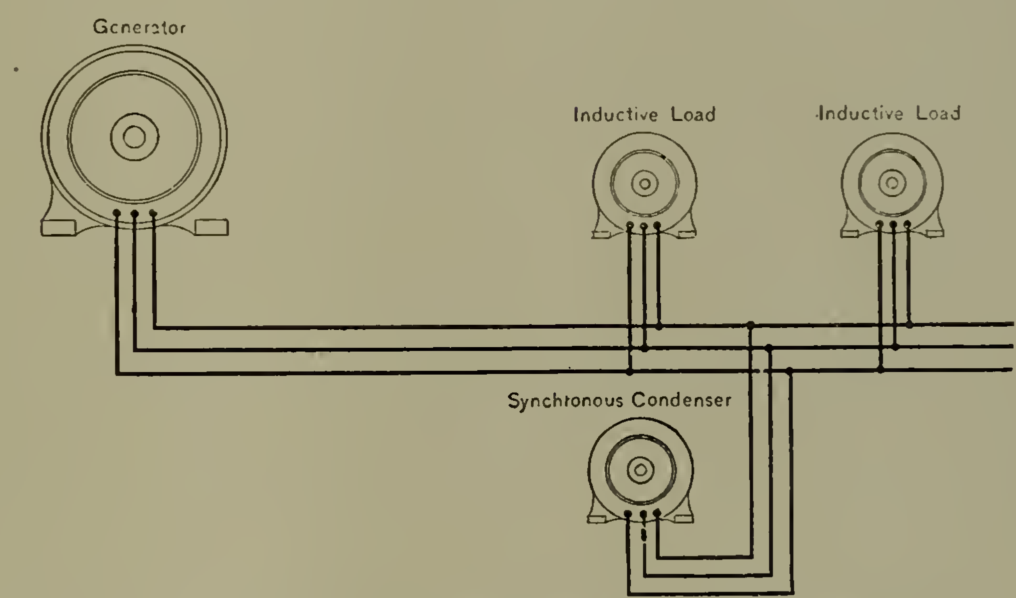


FIG. 1.—DIAGRAM SHOWING SYNCHRONOUS CONDENSER CONNECTED TO A CIRCUIT CARRYING AN INDUCTIVE LOAD.

current, such as a synchronous condenser (in other words, whether the use of a synchronous condenser is justifiable), depends on the additional generating capacity required in the two cases, on the cost of this additional generating capacity (which is largely determined by the relative permissible speeds) and on the saving effected by eliminating the wattless current from the feeders and intermediate transforming apparatus.

The second way of considering the action of the synchronous condenser involves the conception that each pieced apparatus is connected to the circuit takes a certain current from the generator, each current having a certain power-factor—or phase relation to the voltage—depending on the properties of the particular apparatus involved. In parts of the circuit in which several of these individual currents exist the total current is the resultant of the several currents. In order to calculate this resultant current each individual current is resolved into two component currents—one in phase with the voltage, which represents energy, and the other at right angles to the voltage, which is the wattless current. In inductive apparatus, such as induction motors, this wattless component is in one direction from the voltage and is said to be lagging, while in apparatus having the opposite effect—that of capacity—the wattless component is in the opposite direction from the voltage and is said to be leading. Over-excited synchronous motors have this effect of capacity and their wattless currents are leading. In circuits containing several currents, the total current is the resultant of all the separate components of all the individual currents. All the energy components add directly; the wattless components add or substract, depending on whether they are lagging, due to inductive loads, or leading, due to capacity loads. That is, when leading and lagging components exist in the same circuit, they neutralize each other more or less completely, depending on their relative values, and when they are equal they completely neutralize each other and the effect is the same as though neither were present. In this case the total current is equal to the sum of the energy components and the power-factor is 100 per cent. Synchronous condensers, the lagging or inductive wattless currents into the system that neutralize the lagging or inductive wattless currents due to inductive loads. Referring again to Fig. 1, between the generator and the synchronous condenser, the magnetizing or inductive current due to the inductive load is neutralized by the leading current due to the synchronous condenser. It is seen that this analysis leads to the same result as when it is considered that the synchronous condenser directly supplies the magnetizing or lagging wattless current. The first way of looking at the action of the synchronous condenser is simpler and more direct; it is therefore better adapted to purposes of explanation and analysis. The second way, while more complicated, leads directly to the method used in calculating.

It is now possible to explain this method of calculation. This can best be done by means of examples. In working out these examples it will be more convenient to use kilowatts and kilovolt-amperes instead of current. The principle involved, however, is the same.

First, consider a simple circuit consisting of a 50 horse-power induction motor carrying a load of 10 horse-power and the generator supplying current to the motor. Neglect the effect of the line. The motor will have an electrical input with an energy component of about 11 k.w. (taking into account the motor losses) and with a lagging wattless component of, say 20 kilovolt-amperes (determined by the size of the motor). The total input then is 22.8 kilovolt-amperes, being the hypothenuse of the regular triangle of which the energy and wattless components are the two sides. The power-factor of the motor, and also, in this case, of the total load, is the ratio of 11 to 22.8, or 48.5 per cent. It is interesting to note that with the same motor carrying its rated load the energy component would be 41 k.w., the wattless component, which is, neglecting leakage, independent of the load, would be still 20 kilovolt-amperes and the power-factor 90 per cent. This illustrates the bad eqect of underloaded induction motors.

As a second example consider an over-excited synchronous motor carrying an energy load of 300 horse-power and with the field current raised to such a value that the total electrical input taken by the motor is 300 kilovolt-amperes. Under these conditions the energy input, including the motor losses, is about 244 k.w. and the leading wattless component is 175 kilovolt-amperes. The power-factor of the circuit is the ratio of 244 k.w. to 300 kilovolt-amperes, or 81.5 per cent. leading.

Now consider a load made up of a combination of the loads in the first and second examples, only instead of taking one 50 horse-power motor assume 10 such motors each carrying the same load as in the first example. Then the energy component of the total load is the sum of 244 k.w. on account of the synchronous motor, and 110 k.w. on account of the 10 induction motors, or 354 k.w. The wattless components are 200 kilovolt-amperes lagging for the induction motors and 175 kilovolt-amperes leading for the synchronous motor. These two components are directly opposed and their difference is 25 kilovolt-amperes. The combined load is, again, the hypothenuse of a right triangle having 354 and 25 as sides, or, practically, 354, and the power-factor is practically 100 per cent. Considering these figures from the other standpoint, the synchronous motor supplies 175 kilovolt-amperes of the inductive component and the generator supplies the remaining 25 kilovolt-amperes. It is to be remembered that the total inductive kilovolt-amperes remain somewhere in the system.

These examples cover all the calculations involved in the applications of over-excited synchronous motors to power-factor correction. Practical problems, however, present themselves in a little different way, as is shown by the following example:

Assume that a station has a load of 1200 k.w. by wattmeter reading at a power-factor of 70 per cent. A motor-generator set is to be installed which will have a direct-current load of 200 k.w. and it is decided to use a synchronous motor, as part of the motor-generator set, of such size that it can raise the power-factor of the combined load to 90 per cent. in addition to carrying the 200 k.w. energy load. It is desired to know the required rating of the synchronous motor.

First consider the existing load. With 1200 k.w. energy and a power-factor of 70 per cent. the total kilovolt-amperes is 1710. The wattless kilovolt-amperes, as the third side of the triangle, is 1220. Now consider the combined load. The total energy component will be the sum of 1200 k.w. for the existing load and 240 k.w for the motor-generator set, including its losses, or 1440 k.w. This load is to have a power-factor of 90 per cent., in which event the total kilovolt-amperes will be 1600 (1440 divided by .90). This means a lagging wattless component of 698 kilovolt-amperes. It is necessary, then, for the synchronous motor to supply a leading wattless component of the difference between the wattless component of the existing load, 1220 kilovolt-amperes, and of the combined load, 698 kilovolt-amperes. This is 522 kilovolt-amperes. The required capacity of the synchronous motor is, then, the resultant of the energy load (240 k.w.) and the wattless load (522 kilovolt-amperes), or 575 kilovolt-amperes. The power-factor of the synchronous motor itself, it will be noted, is the ratio of 240 to 575, or 41.8 per cent. leading. Here again it may be considered that the synchronous motor supplies part of the inductive kilovolt-amperes required by the inductive load. The total inductive kilovolt-amperes is 1220. Of this the synchronous motor supplies 522 kilovolt-amperes, while the remaining 698 are still supplied by the generator.

If it were desired to raise the power-factor to 100 per cent. instead of 90 per cent. the synchronous motor would have to supply a leading wattless component equal to the total lagging component of the existing load, or 1220 kilovolt-amperes. To raise the power-factor to 100 per cent. the synchronous motor would then have a capacity of 1243 kilovolt-amperes.

If there were no energy load available for the synchronous motor and it were necessary to install the synchronous motor as a synchronous condenser, the rating of the synchronous condenser neglecting its losses would be simply the wattless component, or 585 kilovolt-amperes, in order to raise the power-factor to 90 per cent. and 1220 kilovolt-amperes in order to raise the power-factor to 100 per cent.

It has been previously pointed out that the application of a synchronous condenser in a system simply introduces a source of magnetizing current which replaces a similar generating capacity in the generators. To obtain the same magnetizing effect, however, requires a greater capacity in the synchronous condenser than would be necessary in the generator. The reason for this will be evident when it is remembered that the increase in generator capacity is proportional to the increase in total load, while the size of the synchronous condenser is determined by the magnitude of the wattless component. An example will make this clear. The same figures used in a previous example will be taken. Assume that a station has a load of 1200 k.w., by wattmeter reading, at 70 per cent. power-factor. This load can be taken care of in two ways: First, all of the required capacity can be put in the generator, in which case the generator should have a rating of 1710 kilovolt-amperes and should be capable of operating at 70 per cent. power-factor; second, a synchronous condenser can be installed to take care of the inductive component, in which case the generator need have a rating of only 1200 kilovolt-amperes at 100 per cent. power-factor, but a 1220 kilovolt-ampere synchronous condenser must be installed in addition. In the first case there is a total generating capacity of 1710 kilovolt-amperes in one unit, and in the second case, of 2420 kilovolt-amperes in two units. Obviously, if the speed of the generators is high, so that the cost per kilowatt is no greater than with the synchronous condenser, the plan involving the synchronous condenser will be the more expensive. This is somewhat modified, however, by the fact that, due to the different operating conditions in the generator and synchronous condenser, the latter can be built with approximately 30 per cent. less material per kilowatt than the generator. On the other hand, if the generator is operated at slow speed, say 100 r.p.m., it is evident that considerable saving can be effected by making the synchronous condenser of relatively high speed, say 900 r.p.m. This possible difference in speeds, together with the smaller weight per kilowatt of the synchronous condenser, will in some cases make the plan involving the synchronous condenser less expensive than the larger generator. Under the particular conditions of speed and load used above the 1710-kilovolt-ampere, 100-r.p.m. generator will cost practically the same as the 1200-kilovolt-ampere, 100-r.p.m. generator and the 12,200-kilovolt-ampere 900-r.p.m. synchronous condenser. In favor of the synchronous condenser proposition there is also the possible saving in transformers and feeders and the improved regulation. This is by no means a complete comparison; the switchboard, buildings, attendance, and many other points must be considered; but it indicates that the synchronous condenser at least deserves consideration.

Under some conditions the comparison will be more in favor of the synchronous condenser if the power-factor is raised to only 90 per cent. instead of 100 per cent. It will be noted, in one of the previous examples, that the rating of the synchronous condenser is 1220 kilovolt-amperes to raise the power-factor to 100 per cent., while it is only 585 kilovolt-amperes, or less than half, to raise it to 90 per cent. Using the same data as in the previous paragraph, the rating of the generator should be 1330 kilovolt-amperes at 90 per cent. power-factor and the rating of the synchronous condenser should be 585 kilovolt-amperes in order to raise the power-factor to 90 per cent. The cost of these two units, at 100 r.p.m. and 900 r.p.m., will be about 5 per cent. less than the cost of the 1710-kilovolt-ampere, 100-r.p.m. generator. There is, however, to offset this 5 per cent. gain in cost of generating apparatus, a smaller gain in feeder and transformer cost and considerably less improvement in regulation.

There is another condition under which the use of synchronous condensers may be justified by decreased investment. This is in cases where a large proportion of the investment is in transformers and feeders. The synchronous condenser not only relieves the generators of the magnetizing current but relieves the feeders and intermediate transforming apparatus. That is, with synchronous condensers, the greater part of the electrical apparatus can be of smaller kilovolt-ampere capacity than when all of the system operates at low power-factor. In cases where the transmission and transforming apparatus form a large proportion of the total electrical apparatus the saving in this part of the system alone may easily pay for the synchronous condensers. This assumes that the synchronous condenser is located as near the cause of the low power-factor as possible, so as to eliminate the magnetizing current from as much of the circuit as possible. The ideal condition is to divide the synchronous-condenser capacity into a number of units distributed throughout the system at the various centers of inductive load.

In cases where high-speed generators, such as steam-turbine units, are used, the speed of the synchronous condensers would probably be lower than the speed of the generators. Again, in other cases, with short transmission distances, the saving in feeders may be relatively small. Under these circumstances the use of synchronous condensers would not usually be justified. When low power-factor will prevail and synchronous condensers are not used the size of the generators and other electrical apparatus, in every case, should be increased to take care of the necessary magnetizing current, so that the rating of the engines and generators will be proportionately the same.

A very valuable property of the synchronous condenser will merely be referred to. By means of it the voltage at any point of the system where it may be installed can be maintained constant within certain limits. That is, the synchronous condenser will act as a voltage regulator. This requires that the synchronous condenser be sufficiently large, in proportion to the inductive load, to more than supply the magnetizing current so that the current between the synchronous condenser and the generator will be leading. By varying the field current of the synchronous condenser the voltage at the condenser will be varied, provided there is reactance in the circuit. The field current may be varied automatically, to maintain constant voltage, by a Tirrill regulator. This is very similar to the compounding action of compound-wound rotary converters.

In laying out a new system, or a new feeder circuit or substation in an old system, in which it is proposed to raise the power-factor by synchronous condensers, difficulty will usually be experienced in estimating the probably power-factor of the new circuit. In such cases the following approximate figures for typical installations may be of service:

It is useful to remember that transformers and induction motors take a constant magnetizing current from the circuit, as long as the voltage is constant, independent of their energy load. This may be considered the total wattless component, neglecting leakage. The ratio of their magnetizing component to the rating of the apparatus is reasonably constant. In induction motors this magnetizing component in kilovolt-amperes averages 30 per cent. of the horse-power rating of the motor. In transformers the magnetizing component averages 4 per cent. of the kilovolt-ampere rating of the transformer. For example, if there is a connected load of 500 horse-power in induction motors the constant wattless component of the induction motor load will be 30 per cent of 500, or 150 kilovolt-amperes. This same wattless component will be present whether the motors are running with no load or

Kind of Load.	Approximate Power-Factor
Incandescent lighting with small lowering transformformers	93 per cent.
Series arc lighting with constant-current transformers	From 50 per cent. to 80 per cent. depending whether transformers are carrying their rated number of lamps. An average condition would be 70 per cent. power-factor.
Induction motors	From 60 per cent. to 85 per cent. depending whether motors are carrying their rated load. In applications where the motors will be continuously loaded, such as pumping machinery or air compressors, the power-factor may be as high as 85 per cent. When the motors are underloaded the power-factor will be lower.

with full load. In certain cases this fact gives a convenient approximate means for estimating the wattless component and the consequent synchronous condenser rating.

For purposes of calculation the tables (pages 18 and 19) will be found convenient. The form of the tables is due to Mr. P. M. Lincoln. The two tables differ only in being worked out for kilowatts in one case and for kilovolt-amperes in the other. They can be best explained by showing the method of calculation in each case. In Table I, take 80 per cent. power-factor (vertical line) to be raised to 95 per cent. power-factor (horizontal line). According to the table it will require 42 kilovolt-amperes to increase the power-factor to 100 k.w. from the lower to the higher power-factor. The energy component is 100 k.w.; at 80 per cent. power-factor the total kilovolt-amperes is 125 and the wattless component is 76 kilovolt-amperes.

TABLE I.

TABLE SHOWING K. V. A. CAPACITY OF SYNCHRONOUS CONDENSER REQUIRED TO BRING 100 K. W. FROM ONE POWER FACTOR (VERTICAL LINE) TO A HIGHER POWER FACTOR (HORIZONTAL LINE).

Use this table where load to be compensated is measured by Wattmeter.

POWER FACTOR CORRECTION TABLE.

Power Factor	100	98	95	90	85	80	70	60
100	0							
98	20	0						
95	33	13	0					
90	48	28	16	0				
85	62	41	29	13	0			
80	75	55	42	26	13	0		
75	86	68	55	40	26	13		
70	102	82	69	52	40	27	0	
65	117	97	84	68	55	42	15	
60	133	113	100	85	71	58	31	0
50	173	153	140	125	111	98	71	38
30	318	298	285	270	256	263	216	185
10	995	976	962	947	933	920	893	862

With the same energy component and 95 per cent. power-factor the total kilovolt-amperes is 105 and the wattless component 34 kilovolt-amperes. The difference, which is the required capacity of the synchronous condenser, is 42 kilovolt-amperes, as shown by the table. In Table II take the same power-factors. In this case the table is based on a total load of 100 kilovolt-amperes. Then at 80 per cent. power-factor the energy component is 80 k.w. and the wattless component is 60 kilovolt-amperes. With the same energy

TABLE II

TABLE SHOWING K. V. A. CAPACITY OF SYNCHRONOOUS CONDENSER REQUIRED TO BRING 100 K. V. A. FROM ONE POWER FACTOR (VERTICAL LINE) TO A HIGHER FACTOR POWER (HORIZONTAL LINE).

Use this table where load to be compensated is measured by Ammeter and Voltmeter.

POWER FACTOR CORRECTION TABLE.

Factor	100	98	95	90	85	80	70	60
100	0							
98	20	0						
95	31	12	0					
90	44	25	14	0				
85	53	35	26	11	0			
80	60	44	34	21	10	0		
75	66	51	41	30	20	10		
70	71	57	48	36	28	19	0	
65	76	63	55	44	36	27	10	
60	80	68	60	57	43	36	19	0
50	87	76	70	62	56	49	36	19
30	95	89	85	81	77	73	65	55
10	99	98	96	95	93	92	89	86

load of 80 k.w. (since in practice it is the energy load that remains constant with change of power-factor) and 95 per cent. power-factor, the total load is 84.2 kilovolt-amperes and the wattless component is 26 kilovolt-amperes. The required capacity of the synchronous condenser is 34 kilovolt-amperes, as shown by the table.

THE ELECTRICAL CHARACTERISTICS OF THE SYNCHRONOUS CONDENSER.

The synchronous condenser has been considered, up to this point, entirely in its relation to the system. There are various distinctive qualifications that it should possess, which will now be discussed.

The synchronous condenser operates at practically zero power-factor, leading, the only energy component being its losses. It should, therefore, be rated to carry its normal current at normal voltage and at zero power-factor with the desired temperature rise. Operating at zero power-factor, leading, it will require a large increase in field current beyond the no-load field current. The necessary margin in exciting voltage should therefore be provided.

There being no energy load, the speed may be chosen to suit the electrical conditions. At first thought it would seem that the speed should be as high as the frequency will permit. The most favorable speed, however, is lower than this. On account of the high field current required, caused by the zero power-factor, the field windings become one of the first limitations in the design. A large field loss requires, relatively, a large number of poles to dissipate it, and the speed must be reduced in order to obtain the necessary number of poles.

The conditions of operation of the synchronous condenser are favorable to starting directly with alternating current in the armature winding. Whether or not this method can be used is determined almost entirely by the drop in voltage in the system caused by this method. This is determined largely by the relation between the size of the synchronous condenser and the generating capacity. If the capacity of the generators is several times the capacity of the condenser and exact voltage regulation is not important, there should be no difficulty in starting the synchronous condenser direct. When so started it will require from one to one and one-quarter times its rated kilovolt-amperes for starting. This starting current will have a power-factor of about 30 per cent. If the line conditions are such that this starting current is not permissible an induction starting motor may be used.

The electrical proportions and operating conditions require good damping characteristics to prevent hunting. The necessary damping can in some cases be obtained by using a short-circuited cage winding on the synchronous condenser revolving part similar to the cage winding of an induction motor. When this cage winding is used for its damping properties it should be made of relatively low resistance. This is antagonistic to low-starting current. That is, if good dampers are provided the starting performance must be sacrificed. In most cases, however, it is better to insure good operating characteristics by using low-resistance dampers and to let the starting performance suffer to that extent.

Illumination

Standards and Units of Light

A British candle, according to British law, is the horizontal intensity of the light from a spermaceti candle seven-eighths of an inch in diameter, burning at the rate of 120 grains per hour.

This convenient but inaccurate standard has now been practically replaced by the Harcourt standard Pentane lamp, described below under "Working Standards."

The German candle, or Hefner unit, "Hefner Kerze," designated by H. U., or H. K., is the light emitted horizontally by the von Hefner Alteneck lamp, described below under "Working Standards."

The American candle is based on average values of the British candle, but it is represented by 1.136 Hefner or German candles.

The decimal candle is one-twentieth of the light emitted normally by the Violle standard, which is one square centimeter of platinum at its melting point. This is represented in practice by one-tenth of the horizontal intensity of the Carcel lamp, which is the standard used in France.

The Violle standard is the one most favored by scientists. It was recommended by the Congresses of Electricians in Paris, 1889, and Geneva, 1896.

RELATION BETWEEN STANDARD CANDLES.

Owing to the indefinite character of the British standard and the difference of color between the decimal and Hefner candles, an accurate statement of their relative values is impossible. The following table can therefore be regarded as approximate only.

	British Candle	Hefner Unit	Decimal Candle	Carcel
British Candle	1	1.136	1.04	.104
Hefner Unit	.88	1	.917	.092
Decimal Candle	.96	1.09	1	.1
Carcel	9.6	10.89	10	1
Violle Platinum Unit	19.2	21.8	20	2

UNITED STATES UNIT OF LUMINOUS INTENSITY.

The following letter from S. W. Stratton, Director of the Bureau of Standards, Washington, makes clear the value of the light standard of the United States:

"There is no legal standard of luminous intensity in the United States in the same sense as the units of weights and measures, which have been legalized by distinct act of Congress. Since, however, the Bureau of Standards was instituted by Congress as the custodian of the standards 'adopted or recognized by the Government,' the standards adopted by the Bureau are the authoritative, and in a sense the legal, standards of the United States.

"The standard of luminous intensity as maintained at the Bureau at present is the mean intensity of a large number of seasoned incandescent lamps. At the time of the organization of the Bureau, as indeed is still the case at the present time, the question of primary standards was in a very unsatisfactory condition; and since there was an immediate demand by the public for a definite and fixed unit, it was thought best to establish a practical unit through incandescent lamps and to postpone until a more suitable time the necessarily long investigation of primary standards which must precede the adoption of a primary standard by the United States.

"As the Physikalisch-Technische Reichsanstalt at Charlottenburg was considered the most authoritative standardizing laboratory in existence at the time of the organization of the Bureau, a number of seasoned incandescent lamps with Reichsanstalt certificates were obtained by the Bureau and from these lamps others were made, the mean of all being taken as the standard for the United States. The lamps obtained from the Reichsanstalt were certified in Hefner units, but the Bureau reduced the value in terms of candles, using the ratio 1 Hefner=0.88 candle, which was considered to be the most probable value at the time and which was the value adopted by the American Institute of Electrical Engineers.

"Since the establishment of our photometric unit several comparisons with the Reichsanstalt standards have been made, the last showing our unit as maintained through incandescent lamps to have remained constant to within ½ per cent. We consider this to be an ample justification of our policy. We are hoping, however, to undertake in the near future an investigation of primary standards with the end in view of adopting a suitable primary standard for the United States.

"In reply to your fifth inquiry we would answer unquestionably in the affirmative.* Since any manufacturer or testing laboratory can send to the Bureau lamps to be standardized, as many have done already, there is no reason why there should be any question about the standard of candle-power in the United States.

"In regard to the publication of our position on photometric standards, we have no objection to your printing the information given above, provided you state our position in sufficient detail to insure a perfect understanding. We would not be misunderstood, for example, to hold that incandescent lamp secondary standards should take the place of permanent primary standards. We do hold, however, that until a suitable primary standard for continued use can be found, it is preferable not to adopt any of the existing standards in their present form, but rather to maintain our unit temporarily through incandescent lamps."

A recent bulletin of the Bureau of Standards gives an account of researches by Dr. Hyde on the relative values of the various light standards. Among the important results accomplished by Dr. Hyde is a redetermination of the relative values of the Hefner and the candle, the ratio being found to be .893 instead of .88, as previously accepted. This, however, cannot be accepted as final, owing to the possibility of considerable experimental error.

*Can a lamp maker be held to give a certain intensity of illumination when the "candle-power" only is specified, without stating the standard to which the "candle-power" is referred?

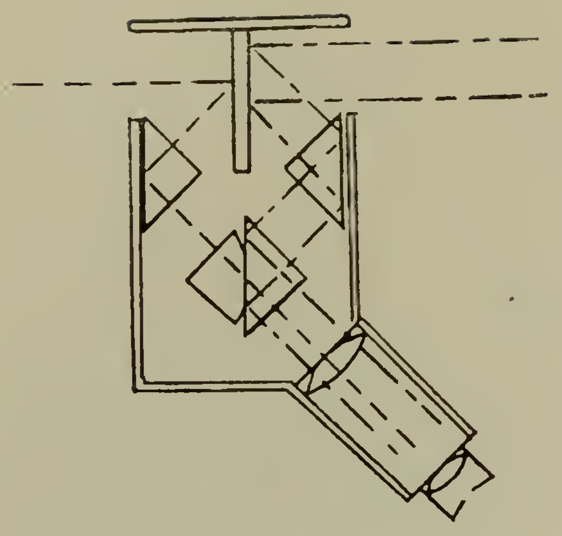


FIG. 1.—LUMMER-BRODHUM PHOTOMETER.

WORKING STANDARDS, GERMANY AND UNITED STATES.

The Hefner candle is the light emitted horizontally by the von Hefner Alteneck lamp. This consists of a small metal body containing the combustible, and projecting from it a metal tube made of German silver which contains the wick. The tube is 8 mm. inside diameter, and 8.3 mm. outside diameter, and 25 mm. high. The wick is formed of strands of cotton yarn, separate threads of which, to the number of 15 or 20, are laid together straight, not twisted, until the size of wick is sufficient to fill the tube without squeezing.

By means of a simple rack mechanism the wick is moved up and down so as to alter the flame height, and by means of a small rod fixed at the top of the lamp, carrying two metal sights, the flame can be adjusted to be exactly of the standard height of 40 mm.

The material burned in the lamp is amyl acetate, $C_7H_{14}O_2$. The quantity of combustible in the lamp does not matter if the lower ends of the wick are well immersed. The lamp is used without a chimney.

The reddish color of the light has prevented the universal adoption of this otherwise excellent standard.

GREAT BRITAIN.

The Vernon-Harcourt 10 c. p. Pentane lamp, although based on average values of light from standard sperm candles, has been practically adopted as the primary as well as the working standard. If the standard candle is defined as one-tenth of the light emitted by this lamp, it is given a definiteness which places it on a footing with the Hefner and Violle units. This is what has, in fact, been done by the action of the Metropolitan Gas Referees in adopting the Pentane lamp as the official standard for the testing of gas in Great Britain.

The Harcourt 10 c. p. Pentane lamp is one in which air is saturated with Pentane vapor, the air gas so formed descending by its gravity to a steatite ring-burner. The flame is drawn into a definite form, and the top of it is hidden from view by a long brass chimney above the steatite burner.

The chimney is surrounded by a larger brass tube, in which the air is warmed by the chimney, and so tends to rise. This makes a current which, descending through another tube, supplies air to the center of the steatite ring. No glass chimney is required, and no exterior means have to be employed to drive the Pentane vapor through the burner.

FRANCE.

The Carcel standard is a lamp burning colza, or rape-seed oil. It gives

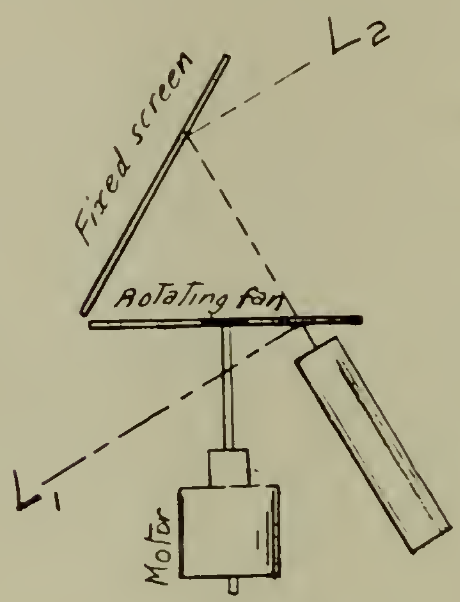


FIG. 2.—FLICKER PHOTOMETER.

almost exactly twice the light of the Violle standard, the decimal candle, therefore, being one-tenth of the Carcel unit.

INCANDESCENT LAMPS AS LIGHT STANDARDS.

The candle-power of new incandescent lamps increases for a short time after they have been put into use. This is due to a decrease in the resistance of the filament. If, however, a good filament is run in a lamp at normal voltage for about fifty hours, it reaches a condition in which a small further use will not much alter it. By that time the glass bulb is blackened, and the lamp will have lost candle-power.

If a filament thus aged is removed from the old bulb and placed in a very large clean bulb, the candle-power will be brought back to nearly its old value, and there will be much less blackening of the bulb. Lamps of this type are said by J. A. Fleming to be very constant. Referring to certain lamps which by comparison with a Pentane standard had shown practically no change in six years, Professor Fleming says: "The results of the measurements are, however, to show that in six years, during which these glow-lamp standards have been much used, the set belonging to the Pender Laboratory have probably remained as constant in light-giving power at the same voltage as the Pentane standard.

Since a standard glow-lamp of this form, used as described in the next section of the paper, is only in a state of incandescence for a few minutes at a time during each test, the use of such a lamp in many hundreds of tests only amounts in all to a few hours.

LIGHT UNITS.

The following units are used to measure photometric quantities other than candle-power:

Luminous Flux.—This is the light emitted by a unit candle through a unit solid angle. If the unit candle is the decimal candle, the flux unit is called a *Lumen*.

Illumination.—This is the illumination due to unit flux on unit area. The unit in the decimal system is the *Lux*, which is a flux of one lumen per square meter.

The candle-foot is the illumination at one foot from a standard candle. One candle-foot=12.21 luxes.

Intrinsic Brightness.—The intrinsic brightness of a source of light is the

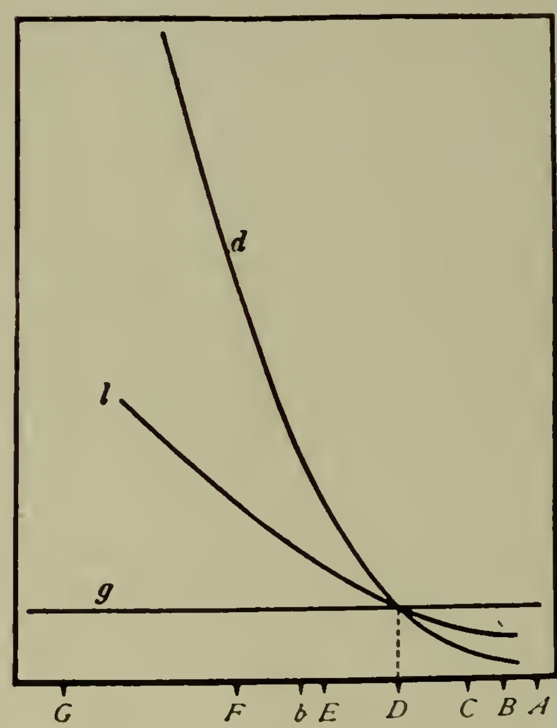


FIG. 3.—COMPARISON OF LIGHTS.*

number of candles per sq. cm. of luminous surface.

The quantity of light is the *Lumen-hour*.

*From "The Electrical World."

ILLUMINATION.

From Das Hilfsbuch der Allgemeinen-Electricitäts-Gesellschaft.

	Hefner Candles per sq. meter of floor.	English candles per sq. of floor.
DWELLING HOUSES:		
Reception rooms	4–5	.33–.41
Living and dining rooms	3–3.5	.25–.29
Bedrooms	1.5–2	.12–.17
Passages, etc	1–2	.08–.17
OFFICES:		
Principal rooms	5–6	.41–.49
Less important rooms	2–2.5	.17–.20
Private offices	1.5–3	.12–.25
SHOPS AND STORES:		
Shops and showrooms	4–7	.33–.57
Office and storerooms	2–2.5	.17–.20
HOTELS:		
Banqueting rooms	9–13	.74–1.1
Public rooms	5–7	.41–.57
Best bedrooms	3–4	.25–.33
Ordinary bedrooms	2–3	.17–.25
Passages	1–1.5	.08–.12
Kitchens, etc	1–2	.08–.17

For shop-window lighting, 3 to 6 lamps per meter or 1 to 2 lamps per foot of window frontage.

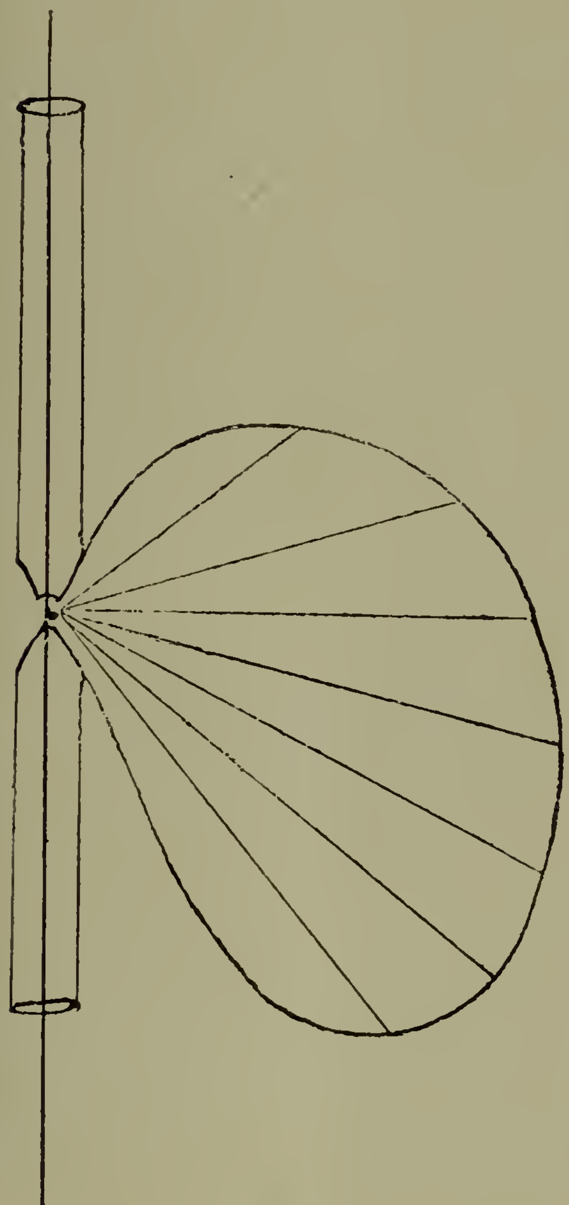


FIG. 4.

FROM FOWLER'S YEAR BOOK.

FACTORIES:	
General Lighting	.05–.1

In addition, each machine should have one or more lamps.

From Franklin & Esty's "Elements of Electrical Engineering."

The intensity of illumination required for easy reading is one candle-foot or 12.21 luxes.

PHOTOMETRY.

The measurement of the light from any lamp is always made by comparing a beam of light from the given lamp with a beam of light from a standard lamp. If the total light from each source is compared, the comparison is called simple photometry; whereas, if the comparison is made wave length by wave length it is called spectrophotometry.

The opinion has been advanced by Lépinay, Nicati and Blondel that the eye possesses a form, or detail, discriminating power, which is not identical with its power of discriminating a difference in brightness. That is, if we equalize the integral brightness on two separate white surfaces, one illuminated by blue and the other by red light, we can more readily distinguish a black pattern drawn upon the surface illuminated by red light than upon the surface illuminated by the blue. Similarly, a black pattern can be more readily distinguished when illuminated by yellow light than when illuminated by blue.

Hence, in addition to simple and spectrophotometry, there is also a photometry of detail-discriminating power.

PHOTOMETERS.

INTENSITY PHOTOMETERS.

These instruments are used in simple photometry to give a general comparison of the luminous intensity of two sources of light.

They all possess the common feature of two surfaces illuminated respectively by the lights to be compared, and differ in the nature of the surfaces and the method of comparing them. The following classification is by J. A. Fleming:

(*a*) Equalizing the illumination of two portions of a semi-transparent or opaque screen formed of paper, porcelain or ground glass, the one portion illuminated by one light and the other by a standard, the equalization being effected by moving the sources of light to various distances.

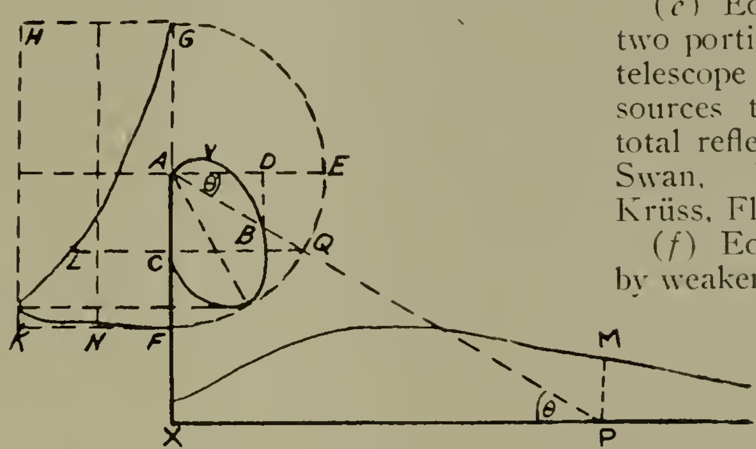


FIG. 5.

When equalization is obtained, the candle-power of the lights will be in the ratio of the square of their distances from the screen.

(*b*) Equalizing the two shadows of a rod made by two lights by moving them to different distances. The simplest form is the Rumford photometer. It has the advantage of not being much affected by stray light.

The intensities of the two lights are in the ratio of the square of the distances from the screen.

(*c*) Equalizing the illumination all over a screen, one portion of which is semi-transparent and the rest opaque.

When a grease spot is made on a sheet of white paper, the spot appears darker than the surrounding space if illuminated from the front, and lighter if illuminated from the rear. If equally illuminated from each side, the grease spot and surrounding paper will appear equally bright. This is the principle of the Bunsen photometer. That of Leeson and Dibdin has a star-shaped aperture in the screen, in which is fastened a sheet of tissue-paper or other semi-transparent material.

(*d*) Equalizing the illumination of two white surfaces inclined at equal or unequal angles, placed in line between the lights to be compared.

A typical and simple form is the Ritchie wedge, in which the two adjacent sides of a white prism inclined at equal angles to the incident rays serve as the two surfaces which are differently illuminated.

Whatever may be the exact nature of the arrangement for creating these two contiguous surfaces illuminated by different sources of light, it appears to be an essential condition for sensitiveness that they shall not be separated by any dark or bright space not illuminated wholly by one light or the other.

Other photometers on the same principle are the Bunsen and Roscoe, Trotter, Thompson and Starling.

(*e*) Equalizing the illumination of two portions of the field of view of a telescope by bringing light from two sources to each part separately by total reflection in prisms. Examples: Swan, Lummer-Brodhun, Weber, Krüss, Fleming.

(*f*) Equalizing two fields of light by weakening one by means of crossed polarizing prisms. Examples: Arago, Zollner, Wild, Salomons, Pickering, Nichols.

(*g*) Equalizing the illumination on two portions of a white surface by weakening one of the illuminations by interposing a rotating disc having cut out of it a sector which can be varied in magnitude. Examples: Fox-Talbot, Napoli, Guthrie, Abney.

(*h*) Equalizing two fields of illumination by the interposition of an absorbing wedge. Examples: Pritchard, Sabine, etc.

SPECTROPHOTOMETERS.

The light from any source can be split into its component colors by means of a prism and each component measured against a standard by means of an intensity photometer.

Ayrton and Perry use an intensity photometer and view the screen through a red and green glass successively, obtaining the ratio of intensities for both colors. The glasses should be ruby-red and signal-green respectively, and should, when superimposed, cut off practically all light.

O. N. Rood uses a method based on flickers. The two sides of a white upright 90-degree prism are illuminated with the lights to be compared, and the flicker is brought about by the rapid motion of a cylindrical lens or biprism of small angle placed opposite the angle of the white prism. The lens is caused to oscillate horizontally by a train of toothed wheels, turned by hand or by a small motor. By this means the two illuminated sides of the prism are presented rapidly in succession to the eye placed beyond an aperture in front of the lens.

The principle involved is that if two surfaces which are differently illuminated are alternately presented to the eye, a certain peculiar flicker is produced, which is destroyed if the surfaces are made equally bright.

Another variety of flicker photometer is that of F. P. Whitman. One source of light illuminates a fixed screen, and the other a revolving semicircular screen of the same material. The screens are arranged so that alternate views of the fixed and revolving screen are obtained. If a flicker is produced, the illuminations of the screens differ. If there is no flicker, the illuminations are equal.

COMPOSITION OF LIGHTS.

The component colors of lights are usually referred to as Fraunhofer's lines, which are the black lines in the spectrum of the sun.

The approximate locations of these lines are:

A, Red (deep).
B, Red.
C, Orange.
D, Yellow.
E, Green.
b, Green (bluish).
F, Blue.
G, Indigo.
H, Violet.

A comparison of gaslight (*g*), limelight (*l*) and daylight (*d*), is given in Fig. 3, in which the three sources of light are of the same intensity at the *D* line. (*Elect. World*, Aug. 4, 1906.)

DETAIL DISCRIMINATION PHOTOMETERS.

These photometers resemble the intensity photometers in most respects, but instead of two plain white screens have two screens ruled with a series of fine black lines on a white background. The lights are adjusted until the lines can be seen with equal distinctness on both screens.

Such a series of lines can be made by ruling on a white surface a number of black lines 1 mm. wide and 1 mm. apart and then photographing to such a size that the width of a line subtends an angle of one minute at ten inches.

In order to overcome the accommodating power of the eye, it is necessary to look at the ruled screens through a small aperture in an eye-piece which constitutes an artificial pupil. The diameter of such a hole may be 1 mm.

INTEGRATING PHOTOMETERS.

Blondel, C. P. Matthews and others have devised instruments by means of which the mean spherical candle-power of a light can be measured by a single setting of a photometer.

SPHERICAL CANDLE-POWER.

Polar Diagram.—The distribution of light around any lamp is usually very uneven, so that a mere statement of candle-power does not by any means completely specify the intensity.

The most complete statement is a polar diagram as shown in Fig. 4 in which the light in any direction is represented by the length of a line in that direction drawn from the luminous source, the ends of all the lines being joined so as to form a closed curve.

The value of such a diagram for practical purposes is illustrated below.

Use of Polar Diagram.—The following graphical method is from J. A. Fleming, The Photometry of the Electric Lamp, *Inst. Elect. Eng.*, 1903, London:

Let *A* (Fig. 5) be a lamp placed on a post *XA* standing on a roadway *XP*. It is required to determine the illumination at any point *P*. Draw the line *AP*, and around *A* set off the polar curve of candle-power of the lamp as determined experimentally. Let *GEF* be a semicircle just touching the polar curve. On the other side of the line *XA* and on the base *FG* describe a rectangle *KFGH*, of which the side *KF* is equal to the maximum radius vector of the polar curve. Draw the horizontal line through *A*, draw a line *BD* vertically through *B*, and through *Q* where *AP* intersects the semicircle draw *QC* horizontally and produce it to *L*, setting off a length *CL* equal to *AB*. At *P* set up *PM* perpendicular to *XP*, and make *PM* equal to the quotient of *BD* divided by $(AP)^2$. This can be done at once by means of a slide rule.

Then if *AB* represent to any scale the luminous intensity of the lamp in the direction *AP*, *MP* will represent the horizontal illumination on the roadway at *P*.

If other radii of the polar curve are drawn and the same construction followed out, then the extremities of all the lines similar to *CL* will define a curve *GLF*, called the Rousseau curve, which has the property that its mean ordinate *FN* is the so-called "mean spherical candle-power of the lamp."

Similarly the upper extremities of all lines like *PM* define a curve *XM*, the ordinates of which define the illumination on a horizontal surface.

If there is more than one lamp, the total illumination is the sum of the separate illuminations.

For street lighting, as a general rule, it will not be necessary to consider more than the two adjacent lamps in obtaining the resultant illumination. We are able, therefore, to set out a curve along a line joining the base of the two lamp-posts showing the maximum, minimum and mean illumination in candle-feet, or any other similar units, on the roadway, and decide exactly as to the proper heights and distances of the arcs to obtain a given result.

Review of The Technical Press

Relays for High-Tension Switch Control

SOME interesting points regarding relays for the control of high-tension switch gear are given by C. C. Garrard in a recent issue of the *Electrical Engineer*, of London.

When maximum inverse time-limit relays are employed the objects sought are twofold: to be able to set the circuit-breaking apparatus at such a value that it will protect the circuit from damage due to heating or overload, and yet prevent the circuit from being opened by every momentary rush of current inseparable from the operation of most systems.

For this purpose two types of relay are used. In both the time required to open the circuit varies inversely as the current. One of them, however, opens instantaneously if the current exceed a certain maximum value, while with the other the curve tends to become asymptotic, and the relay does not open for sudden short, but very heavy, current rushes. This property makes the second type of relay more valuable than the other, because with a series of relays installed to protect different sections of the line, a rush of current exceeding the maximum would open simultaneously all the relays of the first type; yet, with properly selected relays of the second type the proper sequence in opening would be followed.

When connecting maximum-current relays to three-phase systems having the neutral point earthed, a triple-pole relay must be used, fed by three current transformers. On a three-wire, three-phase circuit—that is, one in which the neutral point is not earthed—only two current transformers are required, by reason of the fact that the current in one phase is always equal to the vectorial sum of the currents in the other two. Strictly speaking, it follows that a double-pole relay is sufficient protection for such a circuit, but, for mechanical reasons, it is better to install a three-pole relay.

In selecting transformers for use with relays where heavy currents are flowing, care must be taken that the ratio of transformation does not vary too greatly for heavy loads. Such transformers are usually magnetically leaky, so that the ratio varies. It It should always be specified that does not vary appreciably up to at least 200 per cent. overload. The general rule governing the installation of reverse-power relays is that they should be installed on all circuits which feed bus-bars. Generators should be equipped only with reverse-power relays. Maximum circuit-breaking apparatus should never be installed on them. The reverse-current relay should be set to operate at 10 per cent. of the normal rating of the generator. A lower setting is not desirable, since the circuit-breaker may thus be thrown out if the synchronizing be done rather carelessly.

Preservative Treatment of Wooden Poles

VARIOUS methods now being tried by the United States Forest Service for preserving wooden poles and ties are described by W. R. Wheaton in a recent issue of the *Journal* of the Worcester Polytechnic Institute.

The process used with the most success by the Forest Service is what is known as the open-tank process. This is an application of the old Seeley process. The wood is given a bath of hot oil followed by a bath of cold oil. The poles are submerged in hot creosote oil for a depth to one foot above the ground line, and are allowed to remain in the hot oil for from five to eight hours. They are then either placed in another tank containing cold oil or are allowed to remain in the same oil as it cools.

When the timber is placed in the hot oil, the moisture remaining in the wood is evaporated and the air in the wood cells is expanded. When the poles are changed from the hot to the cold oil or the oil is allowed to cool, the difference in temperature induces a vacuum which causes the oil to penetrate the wood. The poles should always be thoroughly seasoned before treatment. Very few poles have been set long enough to show the efficiency of the various treatments and preservatives. Four years ago the Pacific Light and Power Company of Los Angeles, Cal., set a line of poles from San Bernardino east to the power house at Mentone. Two hundred and one of these poles were treated, forty-three with carbolineum, one hundred and fifty-one with asphaltum and cement, the pole being first wrapped with burlap and then dipped in the compound, and twenty-five with asphaltum and cement with no burlap wrapping. The object of wrapping the pole with burlap is to make the asphaltum and cement stick to the wood. Cement is added to make the asphaltum flexible and adhesive.

Recently one hundred and thirty-eight of these poles were examined, the earth being removed from around the pole for a depth of one foot. The treatment showed results as follows: Of the forty-three poles treated with carbolineum, twenty-seven were examined and found to be rotted through the sap wood in nearly every case; eighty-seven of the poles treated with asphaltum and cement, with the burlap wrapping, were examined and seemingly all were sound.

The asphaltum and cement and the burlap forms a hard shell on the outside of the pole. On twenty-five of these poles the burlap was cut and the wood underneath examined. Of the twenty-five poles, fourteen were sound and the remaining eleven were rotted through the sap wood. Of the twenty-five poles treated with asphaltum and cement without the burlap, twenty-one were badly rotted. The poles examined were cedars from Washington. The poles show a sap wood of ½″ to 1½″ in thickness. This sap wood will rot in from two to three years, but the heart will stand for from eight to twelve years.

A recent publication of the German government gives the life of treated and untreated poles as follows, the figures being taken from statistics on 3,000,000 poles:—

Treated with.	Life.
Sulphate of copper	11 7 years
Corrosive sublimate	13.7 "
Creosote	20.6 "
Untreated	7.7 "

There is no question as to the efficiency of a treatment with creosote. If a sufficient penetration can be obtained, the increase in the life of the pole is assured. The Forest Service has found the open-tank process to be the best as yet tried for the treatments of poles. To obtain the best results the oil should penetrate to a depth greater than the pole will check, and the pole must be thoroughly seasoned before treatment. A treatment with a brush will retard the rot for a time, but the treatment is not an efficient one.

In the South and the East, creosote has made possible the use of loblolly pine for poles and ties, and in the West a penetration of two inches at the six-foot mark of a forty-foot transmission pole of yellow pine has been obtained. This will give this pole a life of at least fifteen years as against a life of three years untreated.

Method of Finding the Effect of Stronger Fields

A METHOD employed in a Western interurban railway repair shop of finding out what would be the effect of putting more turns in the fields of a motor may be of interest to some who suspect that the faulty action of a motor is due to weak fields. This test, says *The Street Railway Journal*, was employed after the failure to locate in the armature or in the setting of the brushes the cause for excessive sparking at the brushes of a motor. The proposition of winding a set of fields with square wire and a greater number of turns to test the effect of stronger fields was being considered, but this would have been rather an expensive procedure.

The accompanying diagram illustrates the manner in which the effects of additional field turns were obtained

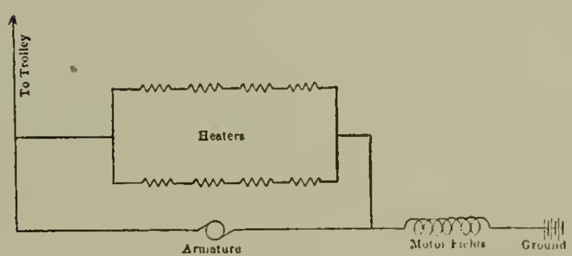


DIAGRAM SHOWING HEATERS IN SHUNT AROUND ARMATURE.

with very little trouble and with practically no expense. The diagram shows the heaters of the car placed as a shunt around the armature of No. 1 motor. When the motors were thrown in multiple the effect of the connections illustrated was simply to increase the current through the fields, while the armature current remained practically the same as without the shunt, because the drop in voltage in the fields of a railway motor is very small, as compared with the drop in the armature. In the test cited the heaters were connected to permit of three gradations of current, and with both of the heater circuits connected in, the current through the field, by actual measurement, was about twice that through the armature, that is, the fields were as strong as they would have been with double the number of turns on them.

A New Type of Motor Generator

A BALANCER of unusual design was recently installed in the power station of the Blankenese-Ohlsdorf branch of the Hamburg Metropolitan & Suburban Railway in Germany. According to the *The Electrical Review*, of London, the machine is designed for generating single-phase alternating-current of twenty-five cycles for operating the railway, an alternating-current of fifty cycles for lighting, and direct current for exciting the alternators and charging an exciting battery. It is connected as a balancer across the three circuits, so that at times it draws power from the twenty-five-cycle circuit, the fifty-cycle machine running as a generator; and at other times operates in the reverse sense.

The machine may also be driven by the direct-current generator running as a motor and drawing its supply from the batteries, but is generally used in this way only for starting purposes. The rotors of the three machines are mounted on the same shaft, the two revolving fields being placed side by side between a single pair of bearings, the direct-current armature being at the other end of the shaft between the central bearing and a second outboard bearing.

The two alternators are each rated at 600 k. w., 6300 volts, when operating as generators. The direct-current machine is rated at 250 k. w., 220 volts. There is a smaller machine of the same kind, in which the twenty-five-cycle section is rated at 250 k. w., and the fifty-cycle part at 150 k. w.

Induction Motor Planer Drive With and Without Fly-wheel

THE ordinary type of metal planing machine has the peculiar feature among machine tools of requiring an excess of energy at the instant of reversal. While the demand for excess energy is but momentary, it may amount to as much as five or six times that used by the machine when cutting. This condition, says H. P. Fairchild in the *Journal* of the Worcester Polytechnic Institute, is made necessary by the use of reverse belts designed to give a reciprocating motion to the planer table by shifting from tight to loose pulleys.

The mechanism provided to shift the belts is designed to snap them into position practically instantaneously. It is essential that this be so, to provide for a sharp and precise reverse with the minimum amount of drifting of the planer table. To render the belts easy to shift, they are kept to a narrow width and then run at a high linear speed to give the necessary power. This leads to a condition as follows: a set of driving pulleys running at a high rim speed which must be brought to rest and then accelerated to a high speed again, but in a reverse direction at the instant; and it is this shock of reversal that calls for the excess energy previously referred to.

To learn something of the conditions which obtain when an induction motor is used to furnish the power to drive a planer, a series of tests were made with a 10-horse-power motor used to drive a 36″×36″×10′ planer. The object was to determine what would be the effect upon the power consumed (1) by changing the length of stroke, and (2) by the use of a fly-wheel upon the planer drive. As a matter of good engineering, it was desirable to keep the weight and diameter of the fly-wheel as small as possible and it was therefore mounted upon the shaft having the highest rotative speed, in this case the motor shaft, itself.

The design of the fly-wheel was sufficient to store and restore energy to take care of the shock of reversal without material change in the speed of the motor. The duration of tests was extended over several days and when averaged and analyzed showed interesting results.

On a planer the capacity of the one tested, the size of the work will usually be such that the planer will be worked at from one-half to full stroke, and the tests were run at one-half stroke for one series and full stroke for the other series. In each series, the readings under the conditions noted were nearly uniform, showing a complete steadiness of running.

The problem easily resolved itself into that of a long stroke with a definite number of reversals to surface a given area, and that of one-half the full length of stroke and double the number of reversals to surface the same area. At one-half stroke or five feet in length, the full width of the planer table was utilized which gave 2160 square inches of surface to be planed. Under the conditions of full stroke, one-half the width was used to give an equal area of surface.

Table No. 1 gives the power consumption in kilowatt-hours and the per cent. of gain under the given conditions.

It will be noted that while the greatest saving is made by using a carefully designed fly-wheel properly placed, there is somewhat saved in mounting the work by grouping to

Table No. 1.

Conditions.	Power consumed K. W. Hours	Per cent. of gain	Cost of Power per Hour	Net Saving per Hour
Short stroke—5 ft. without fly-wheel	1.848	00.0	$0.0924	$0.000
Long stroke—10 ft. without fly-wheel	1.626	12.0	0.0833	$0.009
Short stroke—5 ft. with fly-wheel	1.302	29.5	0.0651	$0.027
Long stroke—10 ft. with fly-wheel	1.240	32.9	0 0620	$0 030

give a maximum length of stroke. This accords with the best planer practice and is interesting from that standpoint alone. The price of electric energy was taken at five cents per kilowatt-hour as a fair average of rates.

Lubrication in the Power Plant

In considering the best manner of getting the oil into an engine cylinder to secure results which will be both satisfactory and economical, the question arises, says *The Street Railway Journal*, does the gravity lubricator meet the requirements, and especially of modern engines? Aside from cylinder oils and their quality entering the question, the application of any lubricant used externally or internally will figure in the answer. All admit that proper distribution on the rubbing surfaces is an essential, yet it is found in practice that the faces of cylinders and valves are cut and scored in streaks, and other parts of the surface show that the lubricant has performed its function in an unsatisfactory manner.

There has been more or less doubt as to the reliability of the existing arrangements for lubricating the valves and cylinders of modern engines, particularly those operating with the higher pressures and steam temperatures of latter-day practice. It often happens that the best lubricating oils will fail to distribute properly on the rubbing surfaces, even when introduced or injected in two or more locations in the pipe, steam chest or the valve bonnets of engines.

Leaving aside questions as to the quality of the oils or the amount used, does not the evidence in the majority of cases point to the fact that a proper distribution cuts the larger figure in the sum of the satisfactory results obtained in cylinder lubrication?

Take a piece of tubing with a smooth interior, swab its inner surface with good cylinder oil, allow steam to pass rapidly through the tube for a few moments, and it will be noted that the interior of the tube has been cleaned from all oil by the process. Such evidence proves that the steam itself is a good medium for oil distribution, provided, however, its velocity rate is sufficient to pick up the oil, atomize and combine with it during its passage. If this be true, does it not prove that the velocity of steam at the valve pot edges contributes materially to the diffusion of the oil in the cylinders, although the valve surfaces lacked lubrication in their bearing ends, the latter being practically dead ends so far as the steam flow is concerned? From this line of reasoning, it follows that a proper distribution would require that the steam be combined with the oil prior to its reaching the rubbing surfaces. General experience shows, however, that a reliable means to accomplish this is lacking, or in other words, any good result is more or less accidental.

The problem seems a complex one, as it will be admitted that some of the best results in lubrication, or properly speaking, distribution, have been obtained by ordinary means; yet a close inquiry into conditions will show that some overlooked feature exists to promote satisfactory results. For instance, take an engine or pump, throttled at its steam supply and the lubricant entering above the throttle valve; then, we have the steam wire-drawing at the throttled opening. The oil for lubrication in this case combines with the increased steam velocity at the contracted openings, resulting in a better distribution than where the oil entered below the throttle. As this condition, however, does not exist in the modern units where the low velocity at the throttle entry is demanded and provided for by large openings, it is very probable that the oil has little chance to be atomized until it reaches the valve faces; at that location it is then swept by the steam, and in a more or less atomized condition into the cylinder.

Such varying results in oil distribution invite a better means for accomplishing the desired end, and the positive oil feed is a step in that direction. It seems to offer a means to saturate the flowing steam with the lubricant, delivering the lubricant at every stroke of the engine, so that the entire rubbing surfaces of valves and cylinder walls are positively lubricated by the oiled steam.

It is possible also that the best lubricant may not give satisfaction, owing to its not being properly distributed on such surfaces, and that the lower grades of oil often give better results, some of the latter possessing the quality of better diffusion (if such a term may be used) by the temperature of the entering steam, the better oil lubricating in streaks, due, perhaps, to viscosity or some other quality which, in a measure, prevents it from being effectively atomized by the steam at the point of oil entry.

An interesting experience in regard to this subject occurred in a power station containing six 36-in. x 62-in. x 60-in. E. P. Allis Corliss cross-compound engines of 2000 horse-power each. The cost of cylinder oil used averaged from 20 to 24 cents per 1000 kilowatt-hours, which proved that enough oil was used to get the best results. Having perfect confidence in the cylinder oil, it was very difficult to locate the reason for this high cost.

Tests were made for moisture in the steam, which only showed about 2 per cent. on full load. The amount of boiler compound was reduced, and, in fact, discontinued for a time. The points of delivery were changed, and other new ideas given a fair trial, yet with the same results.

The engines were stopped and the heads taken off at once, but no trace of oil could be found. The valves and cylinder walls were perfectly dry. After several months of this trouble the chief engineer concluded to replace the gravity lubricator on one engine with a sight-feed oil pump. The result was beyond the expectation of everyone concerned, and proved so satisfactory that all the old gravity sight-feed lubricators were discarded and replaced with this type of pump. The change not only stopped all the cylinder and valve troubles, but reduced the cost per 1000 kilowatt-hours, so that the total cost for all oils has been reduced to 14 cents per 1000 kilowatt-hours.

A review of this whole situation proves that it was not the oil, but the method of application. The gravity lubricator did not deliver the oil into the cylinders as was supposed. While a drop was passing through the gravity lubricator for every four revolutions of the engine, it undoubtedly accumulated in the pipe until there was a quantity of it, leaving the engine to make from 12 to 14 revolutions before receiving any oil; or if the oil did pass into the cylinders, it went in in such large drops that it did not get a chance to vaporize and evenly distribute itself throughout the cylinder.

With the sight-feed pump the oil is delivered into the steam at every stroke or revolution of the engine, feeding the oil into the steam in minute quantities, thus giving it a better chance to atomize and thoroughly saturate the steam. It can be readily understood how great a saving can be accomplished by this method. The pump starts and stops automatically with the engine, giving the valves and cylinders lubrication on the first revolution. The sight feeds are easily adjusted to any number of drops per minute, and the drops are all uniform in size, thereby giving the most perfect conditions for cylinder lubrication.

This type of pump was preferable to the ratchet type of oil pump, as the ratchet type does not feed oil into the steam with each stroke, but is set for the number of revolutions desired for each drop of oil. It is only an improvement over the gravity lubricator inasmuch that when it does feed it is positive.

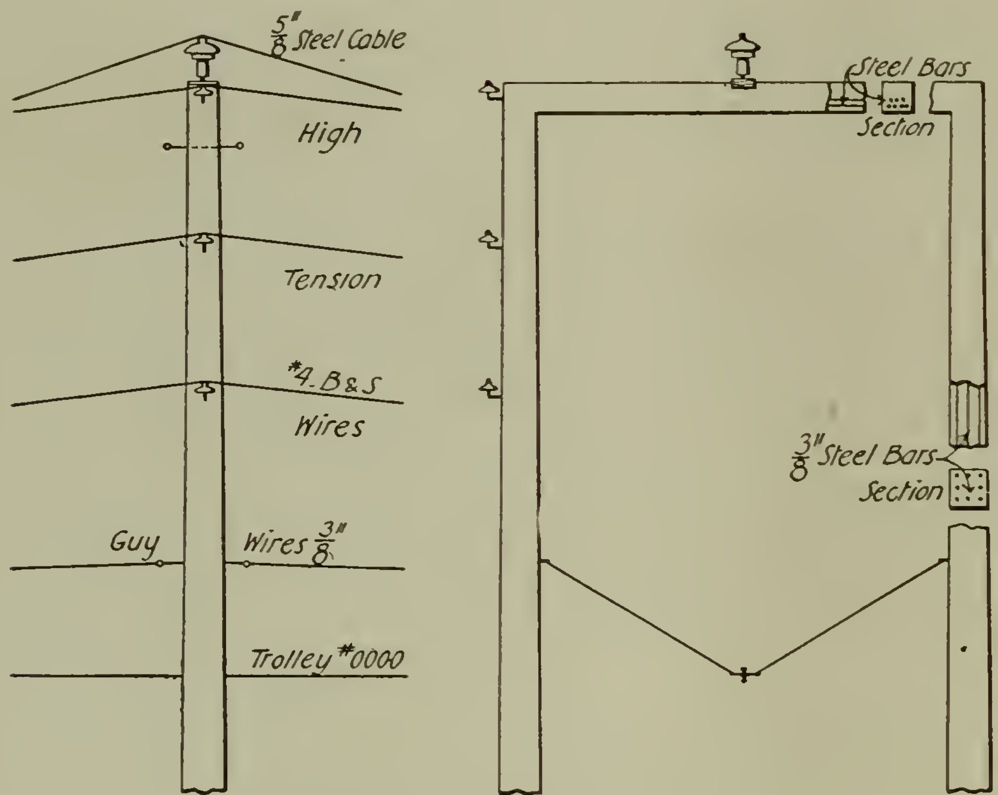
After studying the subject of cylinder lubrication for two years the writer has come to the following conclusions: The power-house valve oil will do the work under all conditions; the gravity-feed lubricator is a failure, as it is not reliable; a ratchet pump is only better than the gravity lubricator as to its positive feed; and that the best results can be obtained by feeding a minute quantity of oil with each stroke of the engine, thereby being sure of the oil atomizing and reaching all the working parts in the cylinder.

Reinforced Concrete Trolley Arches

An interesting method of catenary direct-current trolley suspension, consisting of reinforced concrete arches instead of the ordinary wood or iron poles, is described in a recent issue of *The Electric Railway Review.* This new construction was designed by E. Darrow, Chief Engineer of the Toledo & Indiana Railway. It will be adopted on the company's extension from Bryan, O., to Waterloo, Ind., and will probably be used to replace the present wooden pole construction on the original line from Toledo to Bryan as the pole construction requires renewal.

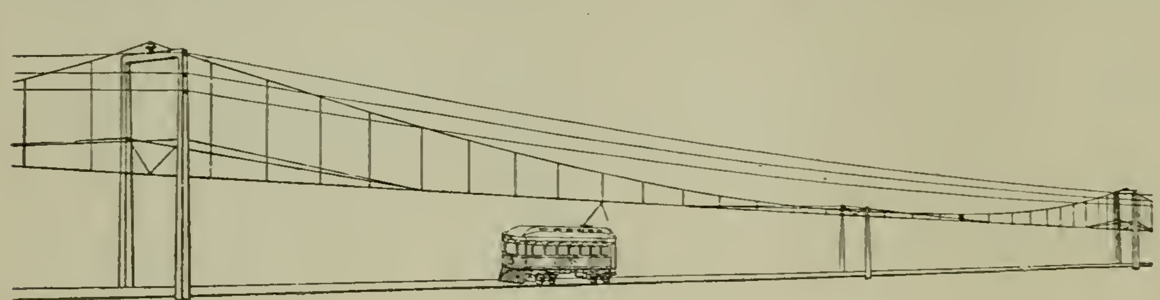
The arches will be set nine feet in the ground and will extend forty feet above the ground. They will be twelve inches square at the base and taper to nine inches at the top. The vertical columns will be reinforced by eight and the bent by seven ⅜-inch steel bars, arranged as shown in the drawing. Midway between the arches, which will be spaced 650 feet apart, will be placed two concrete poles to support the ⅜-inch bridle guys, which are anchored to steel eye-bolts in the concrete.

The trolley will be also braced by bridle guys and sway braces anchored to the sides of the arches, as shown in the illustrations. A ⅝-inch steel cable will be used for the messenger wire which supports the No. 0000 trolley wire. The high-tension wires, of No. 4 hard-drawn copper, are suspended on insulators on the outside of the columns, as shown, spaced thirty-six inches between centers at the points of suspension.



REINFORCED CONCRETE TROLLEY ARCHES.

The cost of one section of the above construction, ready for wires, is $107, as compared with about $90 for the ordinary wood pole construction, with bracket fixtures. This increase in cost is offset by the greatly increased length of life of concrete as compared with wooden poles. The life of an ordinary wooden pole is only about ten years, whereas concrete is supposed to last indefinitely. Another advantage of concrete arches is the comparative freedom from possibility of destruction by lightning.


ANOTHER VIEW OF REINFORCED CONCRETE TROLLEY ARCHES.

Drop in Alternating-Current Circuits

OHM'S law has been practically applied for so long a period by users of electricity as to have become recognized by even the lay fraternity as a synonym for the fundamental principles of the art. E=CR for direct-current and the problem is solved. There is, however, in connection with alternating-current "something different" and the manipulation of more or less involved formulæ leaves in the mind a feeling of insecurity in results which is not present in the case of direct-current calculations.

In the solution of this problem, Mr. Ralph D. Mershon has worked out a method which greatly simplifies the operations. A further simplification, based on Mr. Mershon's method, is given by Messrs. Chas. F. Scott and C. P. Fowler in the April number of *The Electric Journal.*

The usefulness and value of this information cannot be more forcibly shown than by citing a recent instance which came to notice. For the operation of a 150-horse-power motor, power was transmitted 2000 feet over two independent circuits, in parallel, consisting of one No. 00 and one No. 0 line. The drop in voltage was excessive and the remedy first suggested was the addition of a third circuit of No. 0 wire in parallel with the first two, the three circuits being arranged independently so as to secure the least reactance. This would have meant an increase in the copper of 45 per cent. and reduced the total drop from over 25 per cent. to 15 per cent.

A further investigation showed that if the No. 00 circuit be replaced by two circuits each of No. 2 wire, suitably arranged in connection with the No. 0 circuit, the weight of copper would be kept the same and the total drop reduced to 18½ per cent. From this it will seen that the additional 45 per cent. in weight of copper reduced the drop only 3½ per cent. over a rearrangement of the same weight.

This is suggestive of the possibilities of the tables in the present issue, for, while the instance given contemplated the use of multi-circuits, it is equally true that doubling the cross-section of copper in a single circuit reduces the total drop in many cases by a very small proportion as compared

TABLE I—OHMIC RESISTANCE AND APPROXIMATE RATIOS OF REACTANCE TO RESISTANCE.

Size of wire	Resistance per mile of line	Resistance per 1000 ft. of line	Ratio of Reactance to Resistance for the distance between wires of 6″	9″	12″	18″	24″	36″	60″
60 Cycles									
300 000 c.m.	0.365	0.069	2.10	2.40	2.60	2.90	3.05	3.30	3.65
No. 0000	0.518	0.098	1.65	1.82	2.00	2.15	2.30	2.50	2.70
000	0.653	0.124	1.35	1.50	1.60	1.75	1.86	2.00	2.20
00	0.824	0.156	1.10	1.22	1.32	1.44	1.50	1.65	1.80
0	1.04	0.197	0.91	1.00	1.06	1.15	1.22	1.34	1.45
1	1.31	0.248	0.74	0.81	0.86	0.94	0.98	1.08	1.15
2	1.65	0.313	0.60	0.65	0.70	0.75	0.80	0.86	0.94
3	2.08	0.394	0.50	0.53	0.57	0.62	0.65	0.70	0.75
4	2.63	0.497	0.41	0.43	0.46	0.50	0.53	0.57	0.62
5	3.31	0.625	0.31	0.35	0.38	0.41	0.43	0.46	0.50
6	4.18	0.791	0.26	0.29	0.31	0.33	0.35	0.37	0.40
40 Cycles									
400 000 c.m.	0.275	0.052	1.80	2.00	2.15	2.48	2.65	2.90	3.20
300 000 "	0.365	0.069	1.42	1.60	1.74	1.91	2.03	2.20	2.44
No. 0000	0.518	0.098	1.10	1.22	1.32	1.45	1.53	1.66	1.82
000	0.653	0.124	0.91	1.00	1.07	1.17	1.25	1.34	1.47
00	0.824	0.156	0.74	0.82	0.88	0.95	1.01	1.09	1.20
0	1.04	0.197	0.61	0.67	0.71	0.77	0.82	0.90	0.96
1	1.31	0.248	0.50	0.54	0.58	0.63	0.66	0.72	0.78
2	1.65	0.313	0.40	0.43	0.47	0.50	0.53	0.57	0.63
3	2.08	0.394	0.34	0.36	0.38	0.42	0.43	0.46	0.50
4	2.63	0.497	0.27	0.29	0.31	0.33	0.35	0.38	0.41
5	3.31	0.627	0.21	0.23	0.25	0.27	0.29	0.31	0.33
6	4.18	0.791	0.18	0.19	0.21	0.22	0.24	0.26	0.27
25 Cycles									
500 000 c.m.	0.211	0.040	1.40	1.60	1.75	1.95	2.05	2.30	2.50
400 000 "	0.275	0.052	1.15	1.25	1.35	1.55	1.65	1.80	1.98
300 000 "	0.365	0.069	0.89	1.00	1.08	1.20	1.27	1.38	1.52
No. 0000	0.518	0.098	0.69	0.76	0.84	0.90	0.96	1.04	1.12
000	0.653	0.124	0.56	0.63	0.67	0.73	0.78	0.84	0.92
00	0.824	0.156	0.46	0.51	0.55	0.60	0.63	0.68	0.75
0	1.04	0.197	0.38	0.42	0.44	0.48	0.51	0.56	0.60
1	1.31	0.248	0.31	0.34	0.36	0.39	0.41	0.45	0.48
2	1.65	0.313	0.25	0.27	0.29	0.31	0.33	0.36	0.39
3	2.08	0.394	0.21	0.22	0.24	0.26	0.27	0.29	0.31
4	2.63	0.497	0.17	0.18	0.19	0.21	0.22	0.24	0.26
5	3.31	0.627	0.13	0.15	0.16	0.17	0.18	0.19	0.21
6	4.18	0.791	0.11	0.12	0.13	0.14	0.15	0.16	0.17

Note—The resistance in the table is given per mile and per 1000 ft. of line; the length of wire is two miles and 2000 ft. respectively.

TABLE II—DROP-FACTORS WHEN RESISTANCE VOLTS ARE TEN PER CENT. OF THE DELIVERED VOLTS

Ratio of Reactance to Resistance	Drop-Factors for Power-Factors of— 100%	95%	90%	85%	80%	70%	60%	40%	20%
0.1	1.00	1.00	1.00	0.94	0.88	0.80	0.70	0.60	0.30
0.2	1.00	1.01	1.01	0.98	0.92	0.86	0.82	0.67	0.40
0.3	1.00	1.05	1.05	1.02	0.99	0.93	0.89	0.74	0.50
0.4	1.00	1.08	1.10	1.08	1.04	1.00	0.93	0.82	0.60
0.5	1.00	1.11	1.14	1.13	1.10	1.07	1.01	0.92	0.70
0.6	1.01	1.15	1.18	1.19	1.15	1.14	1.09	1.01	0.80
0.7	1.02	1.18	1.23	1.24	1.2!	1.20	1.17	1.11	0.91
0.8	1.02	1.21	1.28	1.29	1.28	1.27	1.24	1.20	1.01
0.9	1.03	1.25	1.33	1.34	1.34	1.35	1.32	1.29	1.11
1.0	1.04	1.28	1.37	1.39	1.40	1.41	1.39	1.38	1.20
1.1	1.05	1.32	1.41	1.44	1.45	1.48	1.47	1.46	1.30
1.2	1.06	1.35	1.46	1.50	1.51	1.55	1.54	1.55	1.40
1.3	1.07	1.39	1.51	1.55	1.57	1.62	1.63	1.64	1.49
1.4	1.08	1.43	1.55	1.61	1.64	1.70	1.71	1.72	1.59
1.5	1.10	1.47	1.60	1.67	1.70	1.77	1.80	1.81	1.70
1.6	1.10	1.51	1.65	1.74	1.77	1.85	1.87	1.90	1.80
1.7	1.13	1.55	1.70	1.79	1.84	1.92	1.95	1.99	1.90
1.8	1.15	1.59	1.76	1.85	1.91	1.99	2.04	2.08	1.99
1.9	1.17	1.63	1.82	1.91	1.98	2.06	2.11	2.16	2.08
2.0	1.18	1.68	1.87	1.96	2.04	2.14	2.19	2.25	2.18
2.1	1.20	1.72	1.92	2.03	2.10	2.21	2.28	2.35	2.28
2.2	1.22	1.77	1.98	2.09	2.17	2.29	2.37	2.45	2.38
2.3	1.23	1.82	2.03	2.15	2.23	2.37	2.45	2.53	2.48
2.4	1.25	1.87	2.09	2.22	2.30	2.44	2.53	2.62	2.58
2.5	1.27	1.91	2.14	2.28	2.37	2.52	2.60	2.71	2.67
2.6	1.30	1.95	2.20	2.34	2.44	2.60	2.67	2.80	2.76
2.7	1.32	1.99	2.26	2.41	2.51	2.68	2.74	2.98	2.86
2.8	1.35	2.05	2.32	2.47	2.57	2.76	2.82	3.07	2.95
2.9	1.37	2.10	2.39	2.54	2.64	2.83	2.91	3.15	3.05
3.0	1.40	2.15	2.45	2.60	2.72	2.90	3.00	3.23	3.15
3.1	1.42	2.20	2.51	2.66	2.80	2.97	3.10	3.31	3.25
3.2	1.45	2.26	2.57	2.73	2.87	3.05	3.20	3.39	3.35
3.3	1.48	2.31	2.63	2.80	2.93	3.12	3.30	3.47	3.45
3.4	1.51	2.36	2.69	2.87	3.00	3.20	3.39	3.56	3.54
3.5	1.53	2.42	2.74	2.94	3.08	3.27	3.48	3.65	3.63
3.6	1.57	2.47	2.80	3.00	3.15	3.35	3.56	3.75	3.72
3.7	1.60	2.52	2.86	3.07	3.23	3.43	3.65	3.85	3.80

with the same result in a direct-current circuit. This is particularly true of circuits of high frequency and low power-factor. The tables in the present issue are a step forward in making easier the calculation of drop in alternating-current circuits and will be very gratefully welcomed.

In the method described the drop or "resistance volts," which would result were a direct current to flow through the circuit, is first determined and then a "drop factor" is found by which the drop with direct current must be multiplied in order to obtain the drop produced by alternating current. The drop factor depends upon three things: (1) the ratio between the reactance volts and the resistance volts, (2) the power-factor of the load, and (3) the percentage value of the resistance volts.

The first of these quantities depends upon the size of wire, the distance between wires and the frequency. Table I gives the ratio of reactance volts to resistance volts for conditions which are most likely to occur.

The effect of the second element, the power-factor of the load is given in a Table II in which the drop-factors for various ratios of resistance volts to reactance volts and various power-factors are given.

The third element, the percentage value of the resistance e. m. f. has a relatively small effect on the value of the drop-factor so that the values given, which are determined for a resistance e. m. f. of 10 per cent., may be accepted as practically correct for all resistance values not exceeding 15 or 20 per cent. The greatest discrepancy occurs when the ratio is high and power-factor is 100 per cent.

In Table I the ratio of the reactance to the resistance .s given for wire sizes ranging from No. 6 B. & S. gauge to 300,000 circ. mils, for sixty cycles and for separations between conductors, ranging from six to sixty inches. In the same table will be found ratios of reactance to resistance for sizes of wire ranging from No. 6 B. & S. to 400,000 circ. mils for forty cycles, and from No. 6 B. & S. to 500,000 circ. mils for twenty-five cycles, both of these covering the same range of wire separations as in the case of sixty cycles. Table I also contains ohmic resistance per thousand feet of line and per mile of line for the various sizes of wire tabulated.

Table II contains various ratios of reactance to resistance which cover approximately the same range as those which appear in Table I. Opposite the ratios in this table are given the drop-factors corresponding to power-factors from 100 per cent. down to 20 per cent. The drop-factors are determined for a value of the resistance

TABLE III—EXAMPLES OF DROP CALCULATIONS IN ALTERNATING-CURRENT CIRCUITS.

Example	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GIVEN														
E.m.f. delivered	1 000	2 000	6 000	10 000	20 000	15 000	40 000	30 000	25 000	400	200	200	400	400
K.w. delivered (real power)	50	75	400	500	1 500	1 200	10 000	6 000	4 000	60	5	10	75	100
Power-Factor (per cent.)	100	95	90	80	60	70	85	80	80	40	20	90	95	80
Number of Phases	1	1	1	1	3	3	3	3	3	3	3	3	3	3
Frequency (cycles per second)	60	60	60	60	25	25	25	25	60	60	60	60	25	25
Size of Wire	4	4	2	3	0	1	300 m.c.m	0000	000	00	5	6	0	0000
Distance between Wires (inches)	12	18	24	24	36	36	60	60	60	9	6	18	12	24
Length of circuit — Miles	......	......	5	10	25	12	40	30	20	......	......	......	......	......
Length of circuit — Feet	2 000	5 000	......	......	......	......	......	......	......	1 000	500	750	1 500	2 000
OHMIC VOLTS														
Apparent K.w.	50	79	445	625	2 500	1 720	11 700	7 500	5 000	150	25	11	79	125
½ apparent K.w. for three phases	......	......	......	......	1 250	860	5 850	3 750	2 500	75	12.5	5.5	38.5	62.5
Amperes	50	39.5	74	62.5	62.5	57	147	125	100	188	62.5	27.5	97.	157.
Resistance volts for unit length — one mile of line	......	......	1.65	2.08	1.04	1.31	0.365	0.518	0.653	......	......	......	......	......
Resistance volts for unit length — 1000 feet of line	0.497	0.497	......	......	......	......	......	......	......	0.156	0.627	0.791	0.197	0.098
Resistance volts for given distance and current	49.7	99.	610	1 300	1 625	900	2 150	1 950	1 306	29.3	19.6	16.3	28.5	30.5
TOTAL DROP														
Ratio of Reactance to Resistance (Table I)	0.46	0.50	0.80	0.65	0.56	0.45	1.52	1.12	2.20	1.22	0.31	0.33	0.44	0.96
Drop-Factor (Table II)	1.00	1.11	1.28	1.15	1.09	1.00	1.67	1.45	2.17	1.55	0.51	1.05	1.08	1.40
Total drop, volts	49.7	109.9	781	1 495	1 771	900	3 580	2 830	2 830	45.5	9.99	17.1	30.8	42.7
Total drop in % of delivered e.m.f.	4.97	5.5	13.0	14.95	8.85	6.00	8.95	9.45	11.3	11.3	4.99	8.5	7.7	10.6
Impressed e.m.f. in volts	1049.7	2109.9	6 781	11 495	21 771	15 900	43 580	32 830	27 830	445.5	209.99	217.1	430.8	442.7

volts equal to 10 per cent. of the delivered e. m. f.

To illustrate the use of the Tables I and II, two examples are here worked and others with varying conditions have been calculated, the data and results of which are given in Table III.

EXAMPLE I—SINGLE PHASE

From Table III it will be seen that in example 1 it is desired to deliver fifty real k. w. at 1000 volts and 100 per cent. power-factor over a single-phase line 2000 feet long composed of two No. 4 B. & S. gauge copper wires, the frequency being sixty cycles and the conductors having a separation of twelve inches.

Ohmic Volts.—The first step is the determination of the apparent k. w., which is obtained by dividing the real k. w. by the power-factor, or 50÷1.00 =50 apparent k. w., which results in a single-phase current of 50,000÷1,000=50 amperes. In Table I, the resistance volts per 1000 feet of line for No. 4 wire are given as 0.497, hence the total resistance volts=2×50 ×0.497=49.7 volts.

Total Drop.—Referring again to Table I, it may be seen that the ratio of reactance to resistance for No. 4 B. & S. wire with 12-inch spacing at sixty cycles is 0.46. In Table II 0.50 is the ratio which is nearest to 0.46, and the corresponding drop factor for 100 per cent. power-factor is 1.00. So that the total drop in volts is 49.7×1.00=49.7 volts, or expressed as per cent. of delivered e. m. f.=4.97 per cent. The impressed e. m. f. would be 1000+49.7=1049.7 volts. In this case, as the drop-factor is 1.00, the total drop is practically equal to the ohmic drop.

The method of working out the next three examples in Table III is similar to the above, all of these being single-phase circuits, with changes in the various other data.

Example 5 is typical of three-phase circuit calculations. In this example, it is required to deliver 1500 real k. w. at 20,000 volts and 60 per cent. power-factor over a 25-mile three-phase line composed of three No. 0 B. & S. copper wires, having a separation of 36 inches, the frequency being twenty-five cycles.

Ohmic Volts.—The real k. w. being 1500 and power-factor 60 per cent., the apparent k. w.=1500÷0.60=2500 k. w. As the circuit is three-phase, the apparent k. w. to be considered in this example are one-half of the total apparent k. w., or 2500÷2=1250 k. w., which gives a current of 1,250,000÷20,000=62.5 amperes. This is the current in an equivalent single-phase circuit delivering half the output with the same per cent. loss and drop as occur in the three-phase circuit.

From Table I the resistance volts per mile of line for No. 0 B. & S. copper wire are 1.04 volts, hence the total resistance volts=25×62.5×1.04 =1625 volts.

Total Drop.—In Table I the ratio of the reactance to the resistance for No. 0 B. & S. wire with 36-inch spacing at twenty-five cycles=0.56. In Table II the nearest ratio to 0.56 is 0.60 and the drop-factor corresponding to this ratio for 60 per cent. power-factor is 1.09. Hence, the total drop=1625× 1.09=1771 volts, or expressed in per cent. of delivered e. m. f.=8.85 per cent. The impressed e. m. f. would be 20,000+1771=21,771 volts.

Niagara Power for Municipalities

THE terms of a contract for a supply of power amply sufficient to fulfil the requirements of those municipalities which have applied up to date, and with provisions for any future demand, have been agreed upon between the Hydro-Electric Power Commission of Ontario and the Ontario Power Company, with the exception of a few minor details.

The contract will call for an amount up to 25,000-horse-power at a rate of $10.40 per horse-power per annum, twenty-four hours a day during the whole 365. If that amount is exceeded, then the price of the whole power delivered is brought down to $10 a horse-power.

The following are among the more important provisions of the contract:

A minimum amount of 10,000-horse-power to be taken, the Commission to have the right to increase this at any time to 30,000 on giving thirty days' notice, and to secure a still larger supply on notice, the time of which will be specifically stated in the agreement. The price to be as stated in the foregoing.

The duration of the contract to be for ten years, with the option of renewal for forty years, or as long as the existing agreements between the company and the Niagara Falls Park Commission remain in force.

The current is to be alternating, three-phase, 25-cycle, 60,000 volts at the transformer station.

Continuity of service to be guaranteed under certain penalties.

The agreed amount of power is to be kept available for the use of the Commission at all times.

Not less than three-quartters of the amount of power contracted for is to be paid for by monthly payments. A condition in this connection is that in case the actual amount taken exceeds the three-quarters, then the basis of payment shall be the gross amount taken for a specified twenty consecutive minutes during the month.

The power is to be measured by standard instruments, sealed and inspected by the representatives of the contracting parties.

Finally, there is a clause vesting in the Commission the right to purchase power from other parties, the amount of which and the territory to be served thereby have not been settled, and will not be, of course, until further demands now being made on the Commission for the supply of power, but not yet put in concrete form, assume that shape.

It is understood the Commission will shortly call for tenders for the erection of poles and the supplying and stringing of wires for transmission lines from Niagara Falls and also for the construction of transformer stations.

An Oiling System in a Large Power Plant

AS affording an example of the latest practice in the design of an oiling system for a large power plant, the facts here given regarding the lubricating oil circulating system in the Long Island City power station of the Pennsylvania Railroad will be of interest. Three systems of oil distribution are provided, one for the turbine bearings, one for the crank cases of the Westinghouse engines, and one for cylinder oil. A plan and elevation of these systems are shown in the annexed illustrations.

The turbine oiling system storage tank is eight feet in diameter by fourteen feet, eight inches deep and is located on the third floor of the boiler house at about the level of the bottom of the bunkers. From the tank the oil flows by gravity to the turbine bearings and thence to a filter tank, from which it is pumped to the storage tank by two 6x10x8½x12 compound duplex Epping-Carpenter pumps, having a capacity of 200 gallons per minute against sixty pounds head. This system is entirely of brass pipe, to avoid all danger of scale.

The oil pumping and filter plant is located in the northeast corner of the turbine room basement. The filtering plant is a two-story chamber, the oil pumps being located on top of it. The second story contains the filters, there being several tiers of pans which carry the canvas filtering bags. The lower floor contains the tanks and the suction connections and valves in the pipe lines leading to the pumps. The system has a capacity of about 8000 gallons of oil. About ten gallons is drawn off each day for various purposes, including the evaporation loss, etc. The oil is circulated through the turbine bearings at the rate of fifty gallons per minute for each turbo-generator, the loss being about one-third of a gallon per turbine-hour.

The oiling system for the crank cases of the Westinghouse engines and auxiliaries includes a storage tank three feet in diameter by ten feet nine inches in height, supplying a gravity of piping which connects with all the Westinghouse reciprocating engines and allows the addition of oil as needed in their crank cases. The discharge from the crank cases is pumped to a filter tank and passes through the filters to a suction tank from which it is delivered to the storage tanks by two 4½x2¾x4 duplex brass-fitted Epping-Carpenter pumps of the piston type. For this system, the return pipe between the engines and the filters is of iron, the balance of the system being of brass with iron fittings. Iron fittings are also used on the brass piping to the turbines.

Cylinder oil is fed by gravity from a storage tank through a system reaching the lubricators on all of the steam cylinders of engines and pumps. Fresh oil is forced into the storage tank from a receiving tank by compressed air.

Below are given the specifications for fittings, valves, etc.:

All lines 4" and larger are to be seamless drawn brass tubing.

All lines smaller than 4" are to be brass except old crank case oil return header and air vent pipes from storage tanks, which are to be full weight black wrought iron pipe.

On lines 3" and smaller, all 90° turns are to be tees with plugs and all 45° turns are to be Y's with plugs.

All check valves are to be Pratt and Cady Check valves with special seats.

Four-inch angle valves on engine oil return at filter are to be E. C. & B. angle globe valves, SCR. All other valves are to be Chapman gates. Valves less than 1¼" to be list No. 1, inside screw. Valves 1¼" and 2½" to be list No. 1 outside screw and yoke. Valves 2½" and larger to be list No. 24 outside screw and yoke.

All supply lines are to be run level.

All return lines are to pitch toward tanks where possible and are to be free from pockets.

All fittings are to be standard weight cast iron.

All fittings 3" and smaller are to be screwed.

All fittings larger than 3" are to be flanged.

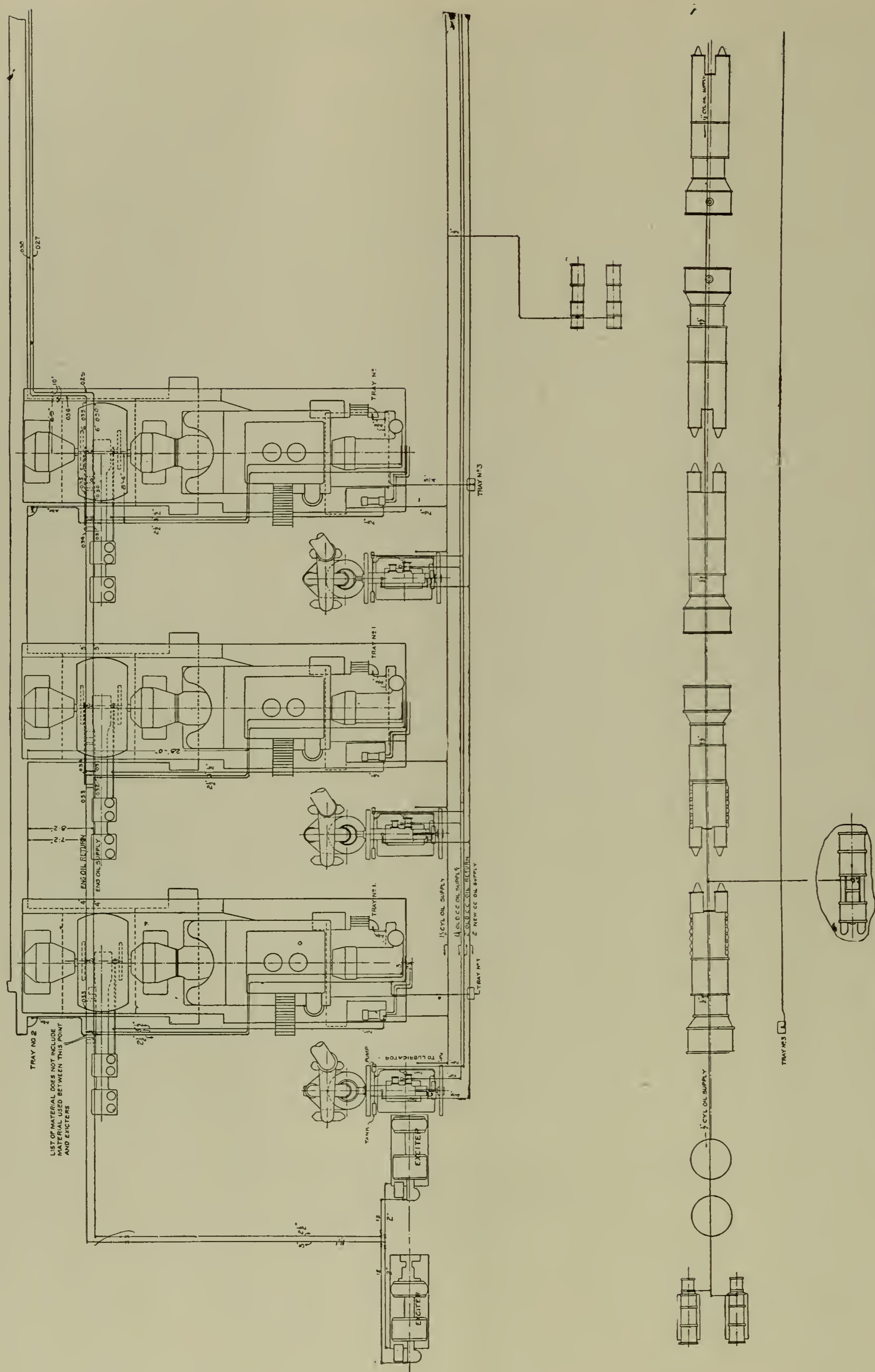
W. I. couplings are to be used where necessary on all lines 3" and smaller.

Standard weight brass unions are to be used where necessary on all lines 3" and smaller.

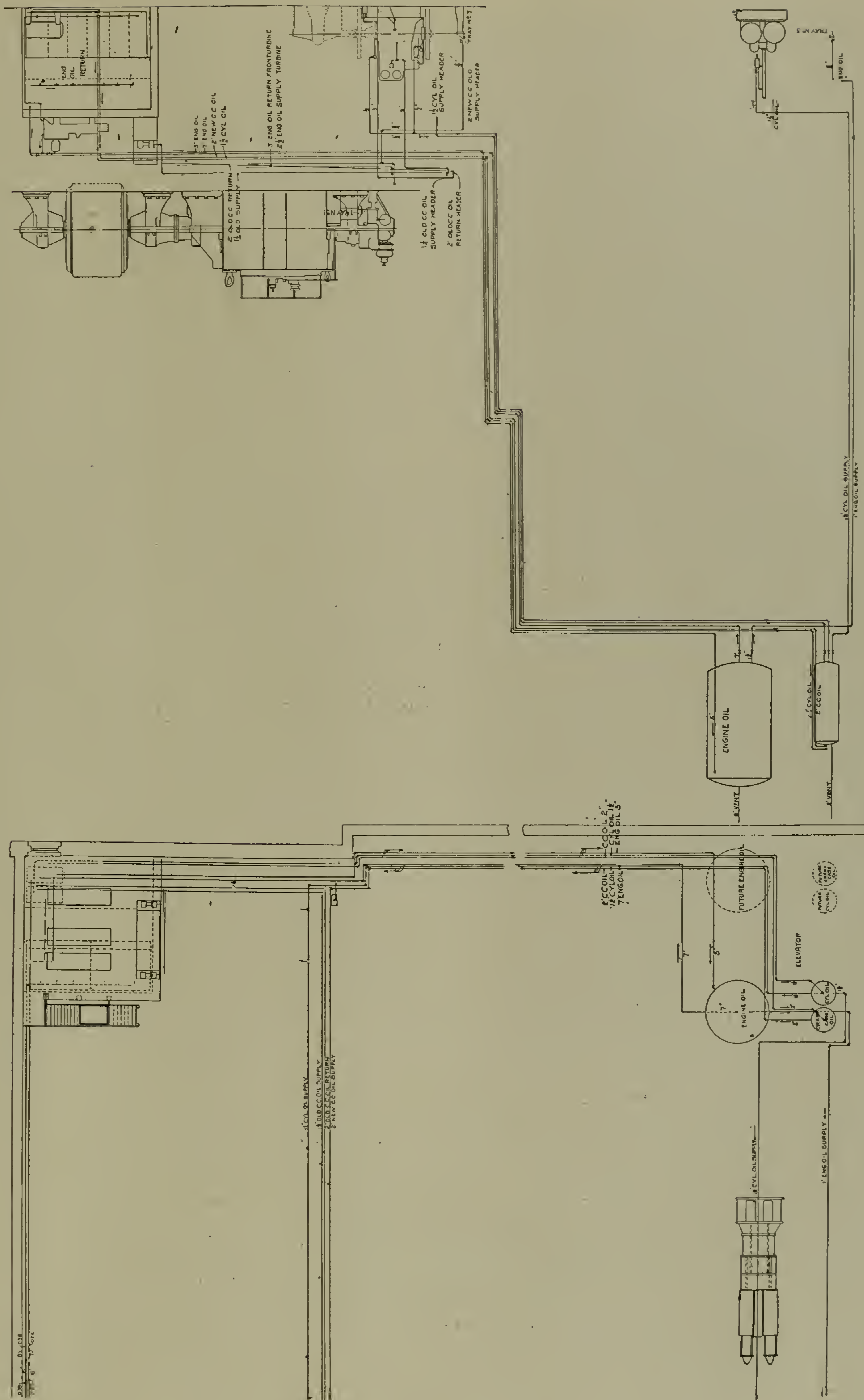
The capacity of the system is made up as follows:

Turbine Oil Tank—holds 376 gallons per foot; total	5,264
Filter Tank—holds 714 gallons per foot; total	2,856
Pipe—holds	753
Each Turbine holds 400 gallons; 3 turbines	1,200
Total capacity	10,073

Maximum amount stored 8,000 gals.



PLAN OF PART OF THE OILING SYSTEM IN THE LONG ISLAND CITY POWER PLANT OF THE PENNSYLVANIA RAILROAD.



PLAN OF THE REMAINDER OF THE OILING SYSTEM SHOWN ON PREVIOUS PAGE

Taking Care of the Central Station Customers

THE principle that a central station must constantly watch over its customers in the matter of giving them efficient service is well set forth by W. W. Edwards, of the Edison Sault Electric Company, of Sault Ste. Marie, Mich., in his paper submitted in the Co-operative Electrical Development Association's 1906 prize competition.

As to equipment, a good photometer is prime necessity. This should be mounted on a suitable carriage and equipped with a full supply of screens, also an attachment for studying reflected light. The latter will be found very valuable, as reflected rays constitute an important part of lighting: the irregular or diffused light being highly desirable for residence illumination. A simple device for studying reflected light is in the form of a large box lined with black cloth, and entirely enclosed except an opening for observation of the interior and a much narrower one for the admission of artificial light. Through this narrow opening a direct ray of light is thrown upon a small reflector, the light being reflected upon any desired surface placed on the opposite side of the interior. By placing samples of wall paper instead of the reflector, the comparative reflecting properties of different shades and qualities of paper may be ascertained. However, this is only a suggestion, but a dark room of some kind is very necessary in this work.

In addition to the photometer, an indicating wattmeter will be necessary or at least very desirable in measuring the load of the different installations. A reliable voltmeter will also be convenient. Each workman in this department shall possess a set of hand tools, such as are used for interior wiring. The department should be supplied with samples of all globes and reflectors in common use, to be employed in making experimental tests.

Besides the above-named equipment, the department itself will invent many devices to aid in the successful conduct of its work. Most of these, as well as the photometer, will be used mainly in testing and making comparisons; a kind of laboratory practice the results of which will be used in actual practice, where the different lighting effects are noted almost entirely by the eye.

This department will have charge of all illumination furnished by the central station. Useful illumination includes or may be considered under these three heads: Residence, Commercial and Street Lighting. Of these, residence and commercial lighting will receive first attention in this paper.

The order of work in the new department will be about as follows: 1st, installation; 2d, improvements; 3d, renewal of incandescent lamps. Both in the installation and in the improvement of lighting service, the new department will work entirely in harmony with existing departments. To this end all work orders will be issued from the main office.

First in order is the work of installation as applied to residence and commercial illumination. When an application is made for electric lighting, the interior wiring of the building usually having been done by contractors, an installation order is made in several copies at the office by means of carbons, a copy being sent to each department having work to do on the installation.

The service department at once runs service lines to the building, or merely connects them as the case may be, while at the same time a man from the illuminating engineering department makes an inspection of the premises and assists the customer in the selecton of lamps, reflectors, etc., best adapted to the particular purpose for which each is to be used. In the efficient use of lamps, an ounce of prevention is worth a pound of cure. Meanwhile a meter is installed by the meter department, an installation receipt being taken for that part of the entire installation belonging to the company.

Every detail necessary for the satisfactory lighting of the premises is considered before leaving, the quality as well as the quantity of the light receiving attention. The customer is thus given to understand from the beginning that the company understands its business and is determined to insure for him the very best results possible. Too much stress cannot be placed upon the importance of establishing and maintaining this favorable impression on the part of the customer.

Improvement in existing lighting service is the next step. Naturally, any complaints regarding unsatisfactory lighting service will receive first attention. Uniformity and promptness of action are secured by means of an operation order which, like the installation order, is issued from the office and is made in more than one copy if the attention of other departments is desired.

Whatever difficulty, it is located and remedied, even though it involves radical methods and some expenditure. Complaints have always existed in a greater or less degree, but it is hoped, and confidently expected, that with the advent of the illuminating engineering department this class of complaints will entirely disappear.

In this connection it may be well to mention two existing difficulties which will cause the new department no little annoyance. One is the tendency on the part of those doing the interior wiring to allow for only a limited number of outlets or to distribute them improperly, regardless of the fact that as much depends upon the efficient use of a lamp as upon the efficiency of the lamp itself. The other difficulty lies in the color and quality of wall and ceiling paper and the shade of interior finish. Many customers will select sombre green or other dark colors, apparently ignorant of the fact that this shade of paper is a powerful absorbent of light and will not reflect more than 12 per cent. to 20 per cent. of the light thrown upon it. While this results in an increased use of current, the gain is more than offset by the annoying complaints of the customer and the misleading reports which he will circulate in regard to the cost of electric lighting.

The opportunities for improvement in lighting efficiency are many, but in most cases the obstructing ideas or existing carelessness must be located by persistent search. The adjustment of a few complaints isonly a beginning. The real aim of this department can be accomplished only by a systematic examination of the premises of every customer on the circuits. In some instances, quite extensive alterations may be necessary, but a satisfied customer is a good customer to have. In order to demonstrate the advantages of making certain changes, it may often be desirable to temporarily install a different kind or size of lamps with suitable reflectors if necessary, the customer signing a temporary installation receipt therefor.

The consumer is at all times given the benefit of valuable advice regarding illumination, and will soon learn to consult this department before making any change in his lighting installation.

As to the renewal of incandescent lamps, great diversity of opinion exists in regard to the proper stage at which it is profitable to remove the incandescent lamp from the circuit. Many central station companies in the smaller cities make no attempt whatever in this direction, except to furnish free renewals as an inducement to customers to return lamps when burned out.

In every well-conducted electric lighting business, the renewals of incandescent lamps are carefully recorded and form one branch of distributing expense; hence the manager knows the monthly expenditure for this purpose, often regarding it as a direct loss.

The useful life of a 3.1-watt lamp at normal voltage is estimated by good authority to be 400 to 450 hours, the 3.5-watt lamp about 800 hours; at which time the candle-power has fallen to about 80 per cent. of rated value. Practical test demonstrates the fact that a lamp which has passed the above period will not conduct as much current as before, the difference increasing with every hour the lamp remains in service.

It is true that the lamp will require more current per candle-power of light delivered, because the candle-power decreases faster than the consumption of current, caused, in part, by the deposit of carbon on the inner surface of the glass bulb causing it to become blackened. On the other hand the total amount of current passing through this lamp in a given time will be less than in the case of a new lamp, chiefly because of loss of conductivity in the carbon-treated filament of the old lamp.

It is safe to say that thousands of dollars are wasted annually by lack of attention to this important principle, enough to repay many times the extra cost of renewals.

The habit of allowing lamps to remain on the circuit after passing the period of their useful life is, therefore, not only an injustice to the customer, by reason of decreased candle-power, but a direct reduction in the earnings of the lighting company. For these two reasons it is imperative that a systematic renewal of lamps be made at stated intervals, these being more frequent during the winter months. Any desired conveyance may be used for this purpose, from a one-horse wagon to an automobile. A record-book containing a record of the number and candle-power of lamps, both delivered and returned, is signed by the customer. In this way the accounting department may not only compute the cost of renewals, but also note any slight changes of candle-power in the customer's installation. Lamps are obtained from the storeroom upon requisition, the same as other supplies. Thus the brilliancy of the incandescent lighting service is maintained unimpaired, resulting in the satisfaction of the customer and in a substantial increase in the earnings of the lighting company.

Necessary accounting.—The addition of the new department need not materially increase the work of accounting. The equipment and tools employed will constitute a branch of Equipment and Tool and Instrument accounts respectively, these being classed as assets.

Salaries and wages, as well as any other operating expenses of the department, will be entered on a running work order sheet, which will be charged monthly to a division of distributing expense known as Illuminating Engineering, only one entry a month being necessary. The temporary installation receipts on hand will at all times show the limited amount of outstanding lamps and other supplies.

The work of soliciting for the sale of light, heat and heating or other electric devices may profitably be associated or even combined with this department if deemed advisable, as the engineering of illumination develops ability for, and leads very naturally to the soliciting of patronage along this and kindred lines.

Approximate Rule for Size of Wires for Three-Phase Transmission Lines

THE following tables, issued by the General Electric Company, are for use in making rough estimates for the sizes of wires for three-phase transmission service:

TABLE A.

Distances to which 100 k.w. three-phase current can be transmitted over different sizes of wires at different potentials, assuming an energy loss of 10 % and a power factor of 85%.

Number B. & S.	Area in Circular Mils.	Distance of Transmission for Various Potentials at Receiving End											
		2,000	3,000	4,000	5,000	6,000	8,000	10,000	12,000	15,000	20,000	25,000	30,000
6	26,250	1.32	2.98	5.28	8.27	11.92	21.12	33.1	47.68	74.50	132.4	206.75	298
5	33,100	1.66	3.75	6.64	10.40	15.00	26.56	41.6	60.00	93.75	166.4	260.00	375
4	41,740	2.10	4.74	8.40	13.15	18.96	33.60	52.6	75.84	118.50	210.4	328.75	474
3	52,630	2.54	5.96	10.16	16.55	23.84	40.64	66.2	95.36	149.00	254.8	413.75	596
2	66,370	3.33	7.51	13.32	20.85	30.04	53.28	83.4	120.16	187.75	333.6	521.25	751
1	83,690	4.21	9.48	16.84	26.32	37.92	67.36	105.3	151.68	212.00	421.2	658.00	948
0	105,500	5.29	11.92	21.16	33.10	47 68	84.64	132.4	191.72	298.00	529.6	827.50	1192
00	133,100	6 71	15:11	26.84	41.97	60.44	107.36	167.9	241.76	377.75	671.6	1049.25	1511
000	167,800	8.45	19.04	33.80	52.85	76.16	135.20	211.4	304.64	476.00	845.6	1321.25	1904
0000	211,600	10.62	23.92	42.48	66.42	95.68	169.92	265.7	382.72	598.00	1062.8	1660.50	2392
	250,000	12.58	28.33	50.32	78.67	113.32	201.28	314.7	453.28	708.25	1258.8	1966.75	2833
	500,000	25.17	56.66	100.68	157.35	226.64	402.72	629.4	906.56	1416.50	2517.6	3933.75	5666

The following example shows how the table may be used:

REQUIRED: The size of wires to deliver 500 k.w. at 6000 volts, at the end of a three-phase line 12 miles long, allowing an energy loss of 10% and a power factor of 85%. If the example called for the transmission of 100 k.w. (on which Table A is based), we should look in the 6000-volt column for the nearest figure to the given distance, and take the size wire corresponding. But the example calls for the transmission of five times this amount of power, and the size of wire varies directly as the distance, which in this case is 12 miles. Therefore we look for the product 5 x 12 = 60 in the 6000-volt column of Table A. The nearest value is 60.44 and the size wire corresponding is No. 00: which is, therefore, the size capable of transmitting 100 k.w. over a line 60.44 miles long, or 500 k.w. over a line 12 miles long as required by the example.

If it is desired to ascertain the size wires which will give an energy loss of 5%, or one-half the loss for which the table is computed, it is only necessary to multiply the value obtained by 2 since the diameter varies directly as the per cent. energy loss.

Exhibit Notes of the Washington Convention of the National Electric Light Association

ALTHOUGH perhaps not as extensive as those at Atlantic City last year, the exhibits of the associate members of the National Electric Light Association at the convention held in the Willard Hotel in Washington proved none the less interesting. Doubtless the fact that less space was available than last year caused several of the exhibitors to rely on photographs rather than actual apparatus to attract attention.

The Allis-Chalmers Company, of Milwaukee, Wis., exhibited photographs in a booth just inside the entrance. A sign in the booth called attention to the company's exhibit at the Jamestown Exposition.

In the booth of the American Electric Heater Co., of Detroit, Mich., a number of electric heating and cooking devices were displayed.

The exhibit of the American Instrument Co., of Philadelphia, consisted of various types of portable and switchboard instruments.

Electric heating and cooking devices were exhibited by the W. J. Barr Electric Manufacturing Company, of Cleveland, Ohio.

The well-known "condulets" were displayed by the Crouse-Hinds Co. Panel-boards and cabinets and the company's "Imperial" arc headlight were also shown.

A number of photographs of various installations were exhibited by the Crocker-Wheeler Co., of Ampere, N. J., who also distributed souvenir postal cards.

In the booth of the Dearborn Drug & Chemical Works, of Chicago, Ill., were shown samples of boiler scales and tubes and valves corroded and clogged by scale.

The solderless connectors of Dossert & Co., of New York, were exhibited in that company's booth. These connectors have been approved by the board of fire underwriters.

The exhibit of the Electric Storage Battery Co., of Philadelphia, Pa., included "Exide" commercial vehicle batteries, central station accumulators, and a recently developed automatic cell-filling apparatus.

The Federal Electric Co., of Chicago, Ill., displayed a variety of electric signs, one of which was operated by a flasher.

The Fiber Conduit Co., of Orangeburg, N. Y., exhibited its several types of bituminized fiber conduit in straight lengths, bends and fittings.

In the booth of the Fort Wayne Electric Works, of Fort Wayne, Ind., were exhibited arc lamps and arc-lamp regulators, transformers, single-phase and multi-phase wattmeters and prepayment meters, and on motors and motor-driven apparatus, as buffers, hand drills and the like.

The tantalum and Gem lamps of the Franklin Electric Manufacturing Co., of Hartford, Conn., were shown with Holophane reflectors of various types. A feature was a reproduction in miniature blue and white lamps of the cable of the new "Noir" lamp.

The Gem, tantalum and tungsten lamps of the General Electric Co., of Schenectady, N. Y., made a brilliant exhibit. Heating and cooking apparatus and a number of direct-current and alternating-current for motors were also displayed.

The well-known "Fancleve" specialties were exhibited by John L. Gleason, and included boxes of various types, switch mounts, receptacles, molding tops and the like.

G. M. Gest exhibited a number of photographs of subway work in Mexico, Canada and the United States. The Gest patent cable rack was also shown.

The exhibit of the H. W. Johns-Manville Co., of New York, consisted of "Noark" subway and service boxes, the "Victor" combination meter, J.-M. junction tape and "Transite" asbestos fireproof doors for high-tension compartments.

The Jardus Electric Company, of Cleveland, Ohio, exhibited a 25-light series arc regulator and board with 10 lamps in circuit. Other exhibits were "Gyrofans," desk fans, absolute cutouts and pendant pull switches for multiple lamps.

The Keystone Electrical Instrument Company displayed a variety of switchboard and portable instruments in the booth of the Jardus Electric Co.

A variety of signs were shown by the Metropolitan Engineering Company, of New York, including a double-face panel sign and an interchangeable sign.

Poles, pins, cross-arms and brackets formed a part of the exhibit of the National Electrical Supplies Company, of Washington, D. C. The Helios flame arc lamp, for use on either direct-current or alternating-current circuits, was also exhiited.

The exhibit of the National Electric Lamp Association was a particularly attractive one, made up as it was by. the various types of high-efficiency units sold by the members of the association. Gem, tantalum and tungsten lamps made the booth a very brilliant place. Not the least interesting were the 1.3-volt tantalum lamps shown.

A number of flaming arc lamps were shown by the New York Beck Lamp Company. Two lamps were operated in series at 110 volts and 60 cycles without the use of starting and controlling mechanism.

The galvanized chain manufactured by the Oneida Community, Ltd., of New York, was shown in use for hanging arc lamps and signs.

Remote control switches were exhibited by the Pettingell-Andrews Co., of Boston, Mass. One of the switches was kept in constant operation by means of a thermostat.

The Philadelphia Electrical & Manufacturing Co. exhibited a model manhole with conduit cables, transformers, etc., and showing its metallic wrappers, sealing plugs, fuse and junction boxes and service-connecting plugs.

The Pittsburg Transformer Co. displayed several light and power transformers and two of 50 and 100-k.w. capacity for 22,000 volts.

Electric cooking and heating apparatus was exhibited by the Simplex Electric Heating Co., of Cambridgeport, Mass., and included a large and a small range.

The exhibit of the Southern Exchange Co., of New York, comprised samples of long-leaf yellow pine for poles and cross-arms, and also Southern cedar for the same purpose.

The Standard Paint Co., of New York, exhibited its well-known insulating compounds, varnishes, tapes, and the like, together with a model house covered with "Ruberoid" roofing.

A wide variety of single and multiple-duct vitrified clay conduit was shown by the Standard Vitrified Conduit Company, of New York.

In the booth of the Wagner Electric Manufacturing Co., of St. Louis, Mo., were displayed several of the company's well-known single-phase motors, of the constant and variable-speed types.

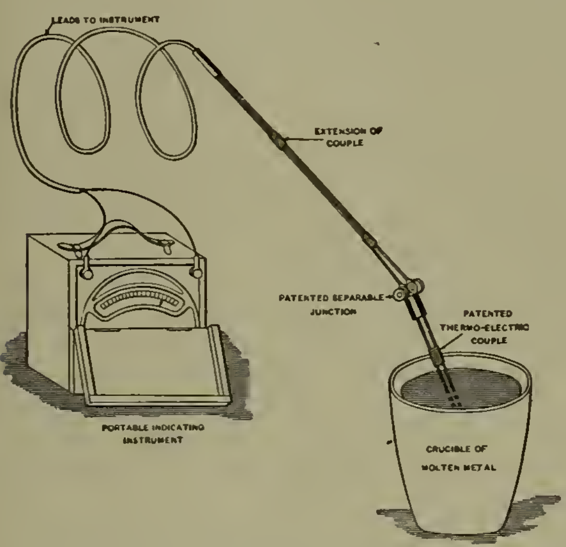
An attractive display was made by the Weston Electrical Instrument Company, of Newark, N. J., consisting of new types of switchboard and portable meters.

The Westinghouse exhibit was extensive, as usual. High-efficiency, metalized-filament lamps, ranging from 20 to 50 candle-power, were shown with tungsten lamps. A new single-glower unit was among the exhibits of the Nernst Lamp Co., and storage battery plates were shown by the Westinghouse Machine Co.

Alternating-current and direct-current fan motors, and direct-current and alternating-current arc lamps were exhibited by the Western Electric Company, of Chicago.

A Portable Pyrometer for Instantaneously Taking Temperatures of Molten Metals

IN manufacturing processes and in metallurgical work molten metals and alloys are extensively employed, especially for the making of castings from molds. It is of the utmost importance that the metals be mixed, alloyed and poured at the proper temperatures in order to obtain the best results. The special form of pyrometer described here has been designed to meet the practical requirements of every-day shop practice. The portable indicating instrument may be carried in the hand, and within two or three seconds the temperature of the molten metal may be taken. The possibilities and great value of an instrument of this kind will be fully



THE BRISTOL PORTABLE PYROMETER FOR MEASURING TEMPERATURES OF MOLTEN METALS.

appreciated by those who are interested in foundry work of any description.

The outfit complete consists of a portable indicating instrument connected to a special thermo-electric couple, the two elements of which are disconnected and left without insulation. When the tips of these elements are slightly immersed into the molten metal, an electric connection is made and the reading on the instrument will be the same as if the couple had been originally joined.

The general arrangement of the parts forming the outfit for this class of temperature measurements is shown in the accompanying diagram as it would be applied for taking the temperature of a crucible of molten metal just before pouring. The advantage of this plan is that the tips of the wires forming the elements almost instantaneously assume the temperature of the molten metal and time lag error is eliminated. This form of couple has been most successfully applied to the measurement of molten metals as cast iron, copper, aluminum, brass, bronze and other alloys.

When the tip of the couple becomes worn away by the continued use, a fresh portion is exposed to the molten metal and the reading will be the same as if the couple had not been reduced. A separable junction is provided, as shown in the diagram, so that fresh tips can be conveniently applied before enough of the couple has worn away to appreciably affect the resistance and cause an erroneous indication on the instrument. These instruments are being successfully used by a large number of manufacturers.

They are manufactured by Wm. H. Bristol, 45 Vesey Street, New York City.

$2,600.00 in Prizes for an Electrical Solicitor's Handbook

THE following extract from a paper by R. S. Hale, of Boston, on "The Value and Use of a Solicitor's Handbook" will be of interest to those who are already competing for the prizes as well as to others who may now contemplate to do so.

The paper above referred to was presented on the Commercial Program of the National Electric Light Association at Washington on June 7, 1907.

"I want now to make a brief announcement of a change in plans in connection with the prize contest for the best electrical solicitor's handbook. The Co-operative Electrical Development Association wrote to all of those who had manifested an interest in the proposed contest last April to find out how they felt about an extension of time in which to submit the competing books.

"By general agreement the time was set for October 1st, next, and all of the competitors must have their work turned in to the Co-operative Electrical Development Association, Cleveland, Ohio, by that time.

"I am sure you all appreciate the value of this contest to central stations and others because of the stimulating of interest everywhere and a fixing of the minds of a great many agents upon the details of their own handbooks through a desire to think up some way by which they could get into this contest.

"I hold in my hands a New York draft for $2,600, which represents the total amount to be awarded in prizes to the successful competitors in this handbook contest. The money will be placed in a bank where it will draw interest until the time the awards are made in October, so that the winners will not only get their prize money but interest on it as well."

Those interested in this subject will be furnished promptly a pamphlet giving full details and particulars upon application to the Co-operative Electrical Development Association, Cleveland, Ohio.

Trade News

At a special meeting of the directors of the Joseph Dixon Crucible Company, held May 31st, to take action on the death of Vice-President and Treasurer, John A. Walker, Geo. T. Smith was elected vice-president, Geo. E. Long treasurer and Harry Dailey was elected director and secretary.

Alfred F. Moore, manufacturer of insulated wire, announces that his Chicago representative, H. E. Cobb, has severed his connection. It is expected that announcement will soon be made of the appointment of a successor.

In announcing the purchase of the Wirt Electric Co., of Philadelphia, the Cutler-Hammer Manufacturing Co., of Milwaukee, desires to state for the information of their customers and those of the Wirt Company, that the manufacture of Wirt apparatus will be continued by the Cutler-Hammer Company. Pending the incorporation in the Cutler-Hammer catalog of apparatus of the Wirt type, the current Wirt catalog should be used. Copies of this catalog may be obtained from the Wirt Electric Co., Philadelphia, the Cutler-Hammer Manufacturing Co., Milwaukee, or on application to any of our district offices. The purchase of the Wirt Electric Co. will enable the Cutler-Hammer Manufacturing Co. to meet, more fully than ever before, the requirements of the trade. For many years certain types of Wirt apparatus have enjoyed an enviable reputation. Particular attention is called to the very complete line of battery charging rheostats developed by the Wirt Co., and to the Wirt field rheostats, which in 1902 were awarded the John Scott medal on recommendation of the Franklin Institute of Pennsylvania. Bulletins covering these and other lines of Wirt apparatus will be furnished on application.

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Electric Trunk Line Operation

THE amount of discussion on the subject of electric trunk line operation is so great that the railroad engineer is left without a definite solution of this problem. Three electric systems have been proposed for the operation of trunk lines, namely, the 600-volt direct current system, the 1200-volt direct current system and the 11,000-volt alternating current system, two frequencies 25 and 15 cycles being proposed for the alternating current system. Besides this choice of systems we have the choice of a third rail or an overhead conductor for transmitting the current to the train.

Where the adoption of electric traction is not compulsory, it may be chosen on account of cleanliness, increased frequency of service or increase in traffic. Since the passenger departments of steam railways now have all the business they can handle, it is not probable that they will adopt electric traction for the purpose of increasing this business, that is, the railroad companies will not adopt electric traction for any reason but for the increase in traffic handled over a given stretch of track. These trains may carry passengers or freight, the object to be attained is to transport a maximum amount of passengers and freight over the railroad. In order to use the railroad at its highest efficiency the trains must be long. The requirements of safety limit the headway between the trains, and when a definite headway is adopted the only method of increasing the traffic is to increase the length of train. With a steam locomotive the length of train is now limited by the strength of draft gear, so that if a railroad company wishes to handle more traffic over its road it must lay additional tracks or adopt electric operation. The laying of additional tracks increases the ability to handle traffic in direct proportion to the increase in trackage. The adoption of electric operation allows of increasing the length of train to an amount limited only by the strength of bridges and embankments. Trains of any length may be operated on any electric system, because several electric locomotives can be made up with the train and operated in unison. Congestion of traffic is also greatly relieved by electric operation, since the electric locomotive can be handled with greater facility than steam locomotives; and, in addition, the make-up of the train being composed of a number of smaller trains each independent of the other, these several trains can be made up at one time each with its locomotive and a complete train may then be formed from a number of these units.

We must then look for the introduction of the electric locomotive into the railway field, first with those railroads having the greatest density of traffic. While the reason for adopting the electric locomotive is generally for the purpose of increasing the ability to handle traffic, the conditions actually encountered require the extension of the electric zone to include parts of the railroad where the traffic is not dense.

The 600-volt direct current system has been evolved from the original street railway 500-volt system. There are several instances where this current is transmitted for distances from ten to fifteen miles, but the loss in voltage is so great under these conditions that the cars cannot be operated at normal speed, nor can the full capacity of the motors be obtained. From five to ten miles is generally considered the limit for 600-volt direct current service. In order to supply a line of track longer than ten miles in length from one power station the electric power is generated by alternating current generators, as it has been found impracticable to generate a high voltage with direct current generators. This high voltage power is transmitted to sub-stations where the voltage is reduced by transformers and converted into direct current by means of rotary converters. The sub-stations are placed from ten to fifteen miles apart, and feed each way for a distance from five to seven miles. The current is carried from the sub-stations to the train by means of a third rail or by overhead conductors.

Since the transmission of electric power at 600 volts is limited to distances from five to ten miles, it is evident that this system is best adapted to those railroads having great density of traffic, such as four-track railroads and terminal yards. In order that there be a load on each sub-station somewhere near its capacity, there should be four or five trains within every length of track of ten to fifteen miles in length, say one train for every three miles of roadway whether there be one, two or four tracks. The load on the sub-station can be made uniform by installing storage batteries, the storage batteries being charged continuously at a uniform rate and discharging when there is a train on the section of tracks supplied by the sub-station. By the judicious use of storage batteries, the 600-volt direct current system can be applied to railroads which have such a low density of traffic that they would not warrant electric operation without batteries. The batteries improve the load factor of the sub-station equipment.

Locomotives for 600-direct current service are slightly cheaper than those for 25-cycle alternating current, and estimates show that with congested service where the sub-station equipment can be utilized to somewhere near its full capacity, it is cheaper to install the 600-volt direct current system. By congested service is meant service in which there is at least one train for every three miles of roadway, regardless of the total length of road. These are the conditions which have led to the adoption of the 600-volt direct current system for street railway service. Street cars are run under short headways, and an approximately uniform load is obtained with this voltage.

The current was at first transmitted to the cars by overhead wires. With the adoption of long, heavy trains the overhead conductor has been found to assume such proportions that it has been replaced by a third rail where possible. At 600 volts the current necessary to operate a long train amounts to 2000 or 3000 amperes, requiring a heavy conductor for transmission. Allowing 800 amperes per square inch cross section of copper conductor, the area for 3000 amperes amounts to four square inches. A copper bar of this size is not readily suspended over the track, consequently it has been replaced by a T-rail located at the side of the track. In terminal yards where there are a number of terminals or crossovers, it is impossible to so locate the third rail that it will allow of contact at all times, and will not interfere with passing cars; for this reason the third rail is inapplicable to terminal yards, complicated crossings and turnouts, and an overhead conductor is erected at these places.

On investigating trunk line conditions it is found that there are very few railroads operating a train every three miles of roadway, and yet the conditions require electric operation at some point. It may be that a terminal station does not permit of handling the number of trains required for the traffic by steam, and that electric operation must be adopted to handle the trains with the available tracks. This is the present state of affairs with a number of railroads. Four or five years ago the 600-volt direct current system was the only system available for traction purposes, a number of railroad companies were obliged to adopt this system to handle their trains immediately adjacent to the terminal yard, the electric locomotives being replaced by steam locomotives for long distance trains. Officials of railroad companies foresaw the difficulties and loss of time incident to the interchange of locomotives at the yard limits, and only adopted the 600-volt direct current system when compelled to do so.

Under actual operating conditions the 600-volt direct current system when applied to railroad operation is found to have two objections: first, the limitations of distance in transmission, and second, the requirements for two styles of conductors, an overhead conductor in terminal yards, and a third rail on the main line. It is, of course, possible to install an overhead conductor for the complete line, but actually the expense and unsightly appearance of the large conductor overhead does not justify its erection except where necessary. Where the time for changing from electric to steam locomotives is not an objection, and where the density of traffic is great, the 600-volt direct current system renders efficient service, especially where storage batteries are installed for taking momentary peak loads.

There are other roads where the density of traffic is too great to be handled by steam locomotives, but which will not justify electric operation at 600 volts. With the introduction of this problem many engineers suggested schemes of operation from a single-phase alternating current trolley among which one has been in operation on a number of heavy interurban lines, and has lately been applied to trunk line service. The system consists of a means of utilizing a single trolley wire at a potential of 11,000 volts. This in itself is enough to recommend the system for all trunk line operation, since the allowable distance of transmission is increased as the square of the voltage. That is to say, the 11,000-volt trolley allows of increasing the length of line found practicable on the 600-volt system to an indefinite length on the 11,000-volt system, the actual allowable length being limited by conditions of traffic. In other words, any railroad having a uniform number of trains in continuous operation can be operated economically by the electric system at 11,000 volts.

By uniform number of trains is meant the number throughout the year. If 100 trains are operated on one day in the year, then the power station must be of a size to operate 100 trains, a definite capital must be invested in this power station and a definite number of men must be employed to keep the machinery in good operative condition. The power station is made of a size to care for the maximum train movement on the entire road. Consider this road to cover a territory of several hundred miles, and supplied by direct current from sub-stations, then conditions may occur such that the entire number of trains must be operated from any one sub-station. If there are ten sub-stations, each to care for the maximum possible number of trains, the investment in moving machinery amounts to ten times that required for the 11,000-volt system, which would be prohibitive. Formerly when railroad companies considered the change to electric operation, the electric companies would make inquiries as to the density of traffic, and if this density was below a set figure they would advise against electric equipment because of the excessive cost for sub-stations. With the perfection of the single-phase alternating system and high voltage trolley, the density of traffic does not have the importance of former years. Its importance now is simply a question of whether the traffic can or cannot be handled by steam, the traffic can always be handled by electric locomotives when power is transmitted at a high voltage.

The benefits of a high voltage are also apparent in the reduction of the amount of current to be collected, the current at 11,000 volts is only 164 amperes for the same amount of power which requires 3000 amperes at 600 volts. The smaller current can be readily carried by small wires, and no difficulty is encountered in erecting an overhead conductor for transmitting this amount of current to the electric locomotive or car. In fact, an ordinary trolley wire construction, properly insulated, would answer all requirements were it not for the importance of maintaining the service and provisions to prevent a breakdown in the line. The trolley wire is therefore suspended from steel strand cables which hold the trolley wire parallel with the track, so that the collector slides smoothly and without vibration. The steel cables are additional protection from the trolley falling to the ground in case it should be broken.

The statement that the distance of transmission at 11,000 volts is unlimited requires some modification. It is true for the conditions as taken, that is, with equivalent feeder cross-sections and taking into account only the ohmic drop in potential. The heavy feeders now installed for street railway service are unnecessary for operation at 11,000 volts, so a reduction in size of feeder is made when operating at the higher voltage. The alternating current system is applicable to operation on roads of several hundred miles in length without expending an appreciable amount for feeders. There is an inductive drop in potential with heavy loads, as in all alternating current transmissions, which drop depends on the frequency.

The first alternating current systems used for lighting were operated at a frequency of 133 cycles. This frequency was found to give satisfactory service for small amounts of power. As the size of the electric installations was increased, the frequency was found to be so high that the inductive drop in potential amounted to a considerable item, even with large wires. The frequency was reduced to 125 cycles, then to 60 cycles, and at the present time the standard frequency for large work is 25 cycles. The adoption of electric operation by steam railroads requires the transmission of immense amounts of power, and if there were no other conditions but the transmission of power to be considered there is no doubt but what a lower frequency than 25 cycles will be necessitated with the immense undertakings in the future. Moreover, the electric manufacturers say their motors have greater outputs at 15 cycles than at 25 cycles, which is an additional reason for going to the lower frequency.

The single-phase alternating current series wound motor has a higher speed at light loads than the direct current motor of equivalent rating. In other words, the series alternating current motor has a steeper speed curve than the direct current motor. I have been told that this is due to the design of the particular motor tested; nevertheless, it is a fact that the series wound alternating motor as now built approaches more closely the requirements of traction service than does the direct current series wound motor. If the two types of motors be started with the same equipment, the controller can be operated to full on position quicker with alternating current motors than it can with the direct current motors to obtain the same uniformity of acceleration. The alternating current motor may be connected to full voltage when running at a lower speed than can the direct current motor to draw the same amount of current from the line in both cases. The reason for this is the change of inductive resistance of the alternating current motor with change of speed. When this motor is run at a low speed it has a higher inductive resistance than at a high speed; its construction is such as to automatically regulate the supply of current. The effect of this improved operation of the alternating current motor is apparent in the reduction of control steps made possible; it is also apparent when the train is in operation and encounters a slight grade, the motors slow down to a slower speed on heavy grades and on going around curves than do the direct current motors of the same makes. The ideal motor for traction service is one which operates at its normal rating at all torques. This characteristic may be represented by a curve plotted with horse-power as ordinates and torque as abscissæ. The horse-power output of the series wound alternating current motor more closely approximates constant values for all torques than does that of any of the other motors. The series wound alternating current motor can be connected to normal voltage with the train running up grades and around curves; it protects itself. This may be due to the particular design of the motor selected, but curves fairly representative of all makes of motors give the impression that the higher motor impedance at low speed is the real factor acting for the betterment of service. The efficiencies of the alternating current and direct current motors are closely the same, though it is doubtful whether the actual amount of coal burned is of great importance to a railroad. It is more important to keep down the initial expense for power equipment and the higher trolley voltage of the alternating system results in the power station or substation equipments supplying such a length of track that the load factor on these stations is maintained at its highest value.

Any other system utilizing a high voltage trolley will supply the requirements of electric trunk line operation. One system, consisting of single-phase motors operating in conjunction with air compressors, gives promise of good results; another system, in which rotary converters are mounted in the locomotive for supplying direct current to the operating motors, allows of the use of a high voltage trolley and the application of induction motors to railroad operation has been practised in European countries. The primary object to be attained is the transmission of electric power to the locomotive at a high voltage. The high voltage trolley is what makes the electric trunk line operative; it increases the scope of electric operation from street railway and interurban lines with small trains running under short headway to include also trunk line service of heavy trains with the present schedules of freight and passenger service. This is not always desired; frequently suburban trains and terminal service only are to be electrified, in which case the 600-volt service is found cheapest when the density of traffic is great.

There is another class of service which includes traffic of moderately long hauls with headways between trains too long to allow of economic operation at 600 volts. A high voltage direct current system has been proposed to care for this work. The direct current transmission of power is extremely desirable; there is no inductive loss in voltage, and the full capacity of the generators can be utilized for operating the cars. This same result is obtained, however, by reducing the frequency of the alternating current so that with equal trolley voltages the direct current and 15-cycle alternating current are about on a par. But a railroad is now being operated on the alternating system with a trolley voltage of 11,000 volts, while the highest proposed voltage of the direct current system is 1200 volts. This difference is far too great for these systems to be competitive in trunk line operation. There is a field for the 1200-volt direct current if the motors can be made cheaper or better than the alternating current motors, which would include railroads of moderate density of traffic though it would not be applicable to many of the present trunk line roads with their present schedules.

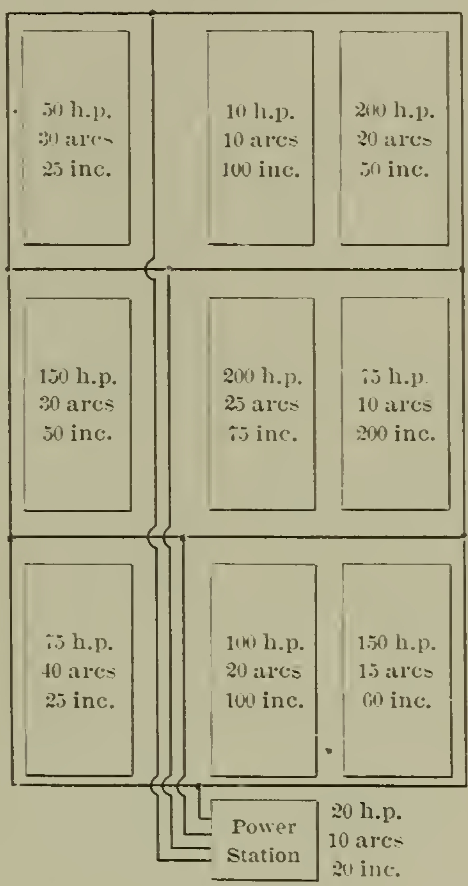
The 220-Volt Direct Current System of Distribution

FOR shop equipment, when a variable speed motor is essential and the distances of power transmission are not too great, the 220-volt direct current system of distribution is found advantageous. By adopting this system the cost of the motor equipment is reduced and the cost of the transformers required for alternating current systems is saved at the expense of a greater outlay for feeders than is required for the alternating current systems. Moreover, arc and incandescent lighting can be supplied at 220 volts, which is not possible with a higher voltage unless by burning several lamps in series, a complication which is not desirable. The undesirable feature of all direct current systems is the short allowable distance of transmission. A method is here proposed for overcoming the evil effect of a large drop in potential in the distributing system in so far as the service is effected, it, of course, being impossible to save the power lost in the feeders.

The method suggested is to divide the switchboard bus bars at the power station into sections and to operate the generators supplying these sections at different percentages of over-compounding. Feeders supplying remote districts would be connected to those sections of the station bus bars supplied by generators most heavily over-compounded. Those feeders which supply intermediate districts would be connected to bus bar sections having a slight rise of voltage with increase of load and the feeders which supply the shops and buildings immediately adjacent to the station would be connected to generators having a straight level voltage characteristic.

Modern direct current generators make this system of distribution possible. These generators are supplied with series windings to give a voltage at full load 5 per cent. higher than the voltage at no load, and have resistances connected in parallel with the series field by means of which the degree of over-compounding can be varied at will. The greatest effect of the series field is obtained when the resistance connection is opened. When the resistance is connected in circuit a part of the current is diverted from the series winding, thus reducing the effect of the series field with any given load. As the resistance is decreased in ohmic value, a greater proportion of the total current flows through the shunt with consequent reduction of current in the series field, and reduction of voltage at a given load. The resistance can be adjusted at will for any degree of over-compounding.

A shop layout has been assumed as shown. Light and power loads are indicated for each building, and for the yard amounting to a total of about 900 kw. The motor load amounts to 750 kw., or approximately 80 per cent. of the total. Evidently with this preponderance of power load a system should be chosen which is best adapted to motor operation, the lighting load



SHOP LAYOUT.

being considered of secondary importance. It is possible to install a third wire for obtaining 110-volt service, and this voltage gives a higher efficiency of illumination than is obtained at 220 volts. Some complication and expense is involved, however, by the erection of the third wire, and its addition would not be warranted except by improved motor service. Several manufacturers are now making variable speed motors for operation from a single voltage, so that the question of the number of voltages required depends on the relative cost of the extra wires and the improved results obtained with multi-voltage variable speed motors.

When the single voltage motor is found to have a sufficient range of speed for the work to be done, standard two-wire generators can be adopted for both light and power. The troubles formerly experienced with burnt-out resistance in 220-volt arc lamps have been overcome by improved methods of insulation and ventilation; 220-volt incandescent lamps are now made with a life comparable with that of 110-volt lamps of equal efficiency, and 220-volt motors give a wide range of speed on a single voltage.

With the load as indicated, either four 200 kw. or four 250 kw. generators will supply the total demand. When the entire load is carried, the four 200 kw. generators are overloaded by 12 per cent., which would not be a severe overload unless one of the machines requires repairs, in which case the remaining three generators would be overloaded 50 per cent. The four 250 kw. generators have the desirable feature of allowing one machine to be shut down for making adjustments and the remaining three generators will carry the entire load for several hours without excessive heating. The four 250 kw. generators appear to be the most desirable selection.

The system as proposed would consist in dividing the bus bars into four sections for this particular installation, one generator and one feeder being connected to each section; or where there is no immediate prospect of an increase of station capacity, the bus bars may be omitted entirely and the generator leads extended as feeders. Usually the conditions do not allow of this simple connection of feeders and generators, as the number of feeders and generators cannot always be made the same. Where the conditions do allow selecting a number of generators equal to the number of feeders, the station switchboard is simplified by omitting the bus bars.

Equalizer connections between compound wound generators are so universal that the question of parallel operation without an equalizer bus immediately causes comment. It must be remembered, however, that the load is connected through the feeders, and that these feeders have an appreciable resistance. For instance, the generator supplying the shortest feeder will operate in parallel with the generator supplying any other feeder when the voltages at the far ends of the feeders are equal. The generator supplying the shortest feeder would be adjusted for a level voltage characteristic, that is, the voltage will not increase or decrease with the load, suppose this voltage to be 200 volts for all loads. The next shortest feeder may have any drop in potential at full load; take the calculated drop as four volts, then the generator supplying this feeder should be adjusted for 2 per cent. over-compound, giving 224 volts at full load, and 220 volts at no load. The voltage at the end of this feeder will then be 220 volts at all loads. Also, there is no danger of this generator feeding back through the shortest feeder, and running the first generator as a motor for the potential at the end of the feeder can never rise above 220 volts. Similarly the generator supplying the third feeder would be over-compounded to compensate for the drop in potential in this feeder, likewise for the fourth feeder and its generator.

There is an objection to this system, in that the generators will not divide the load equally when the load on the system is greatest near the point of connection of one of the feeders. This objection is partially overcome by supplying each building from two feeders; thus, when one building only is in operation, its entire load will not be carried by one feeder, or will one generator be required to carry much the greater part of the load when two generators are in operation. The load can be exactly adjusted to equal amounts on all the generators by adjusting the generator field rheostats in the same manner as now employed when the generators are connected to a bus bar.

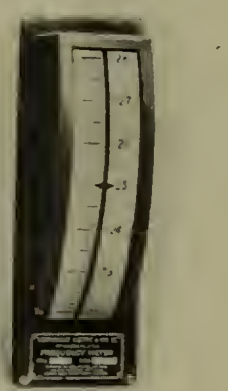
At times of light load it is only necessary to operate one machine for the entire shop equipment, for the drop in potential due to losses in transmission will be small with small loads, and the voltage at the load will be nearly normal. Generators supplying intermediate feeders will give the best results for single operation, though with the size of feeders required to carry full load current the drop in potential at small loads will be inappreciable, and the advantage of generators supplying intermediate feeders over those supplying end feeders will be so slight that any generator may be operated with equally good results.

The advantage of the system as proposed consists of a uniform voltage maintained at the load without the expense of boosters or other voltage regulating devices.

Induction Type Frequency Meters

By PAUL MAC GAHAN and H. W. YOUNG

OWING to the fact that the induction motor changes its speed with change of frequency, it is essential that the supply current be maintained at the normal frequency as any change in motor speed affects the driven machinery, and if the speed is below normal the output of machines will be lowered, this cutting down the product depending in amount upon the per cent. of speed drop. This is especially true of circuits which supply induction motors driving machinery requiring constant or fixed speeds, such as motor-driven textile machines where any variation from the normal



INDICATING FREQUENCY METER.

is undesirable, not only to insure a better and more uniform product but also to eliminate as far as possible the complaints of operators claiming that the machine speed is low or variable, thus accounting for under-production or imperfect output.

The necessity of maintaining satisfactory service has, therefore, developed a demand for accurate, simple and reliable direct reading frequency meters uniform in appearance with other indicating meters, thus contributing to uniformity of switchboard appearance and construction.

Aside from their importance in connection with motor installations, they are also extremely useful on all switchboards controlling alternating current generating system as their use enables the operators to determine at any time if the prime movers are maintaining their proper speed. Irregularities in the operation of engine or waterwheel governors can be detected, and by constantly calling speed variations to the operator's attention the frequency meter serves a useful purpose in contributing to more accurate governor adjustments.

A very satisfactory form of frequency meter has been developed to operate upon the "induction" principle and a short description of this type may prove of interest to those interested in the use of alternating current machinery.

Fig. 1 illustrates the general arrangement of the various elements in which A-B are two fine wire coils, each mounted on a core C of laminated iron assembled in such a manner as to present the air gaps C′-D′. Enclosing one-half of each iron core forming the lower side of gap is a heavy copper loop short circuited on itself.

The aluminum disk G, one-half of which is circular in contour and the other half slightly spiral, is mounted on a pivoted shaft and so located that the circular half passes through the gap C′ and the spiral half through gap D′. This pivoted element (Fig. 2) is perfectly balanced and is not provided with any controlling or restraining force, as is usual with the majority of indicating meters. The pointer is arranged to pass over a suitably graduated dial calibrated to read in cycles. Uniform scale divisions are obtained by a suitable contour of the spiral edge of the disk.

In conjunction with the meter is used a non-inductive resistance H and

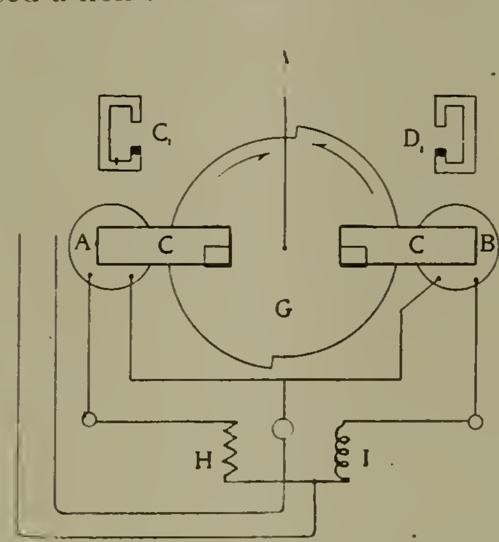


FIG. 1.—CONNECTIONS OF FREQUENCY METER—INDICATING TYPE.

an inductance I, the former being composed of high resistance low temperature coefficient wire and the latter consisting of a large number of turns of wire wound on laminated iron. The elements H and I are external and secured in a suitable ventilated cage for mounting apart from the meter.

As will be seen from Fig. 1, coil A is connected to line through the resistance H, coil B is connected to the same side of line through reactance I, and the common connection of A and B made directly to the opposite side of the line. This arrangement gives two circuits in parallel, one of which, B-I, is highly inductive.

The meter being of the "induction" type, depends for its action upon the reaction of magnetic fields displaced in relation to each other, and in this design the necessary displacement is secured by the action of the short circuited loops E-E, which produce a

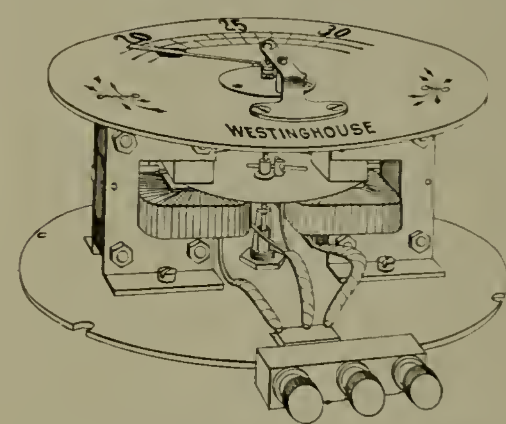


FIG. 2.—CONSTRUCTION OF FREQUENCY METER—ROUND DIAL INDICATING TYPE.

phase displacement between the enclosed and non-enclosed flux of the magnetic fields of coils A and B, so that the eddy currents generated in the disk by each react upon the other flux and produce a torque tending to rotate the pivoted disk G.

The action of the meter depends upon the torques exerted by the coils A-B, each of which tends to rotate the disk in the direction of the arrows, so that with equal torques on both elements the disk remains stationary and at normal frequency indicates the proper scale mark. As previously stated, the electro-magnet coil A has in series with it a non-inductive resistance and the coil B an inductance, so that as the frequency of circuit increases the current in coil A remains practically the same and that in coil B decreases in proportion. The torque exerted by each on the disk is proportional to the square of the current in the coils, and to the frequency.

Therefore, the torque due to coil A will increase with frequency; that due to coil B will decrease owing to the decrease of current in same and the disk will move. As there is no controlling spring on the shaft, the disk will move until the difference of diameters of disk within the influence of the two electro-magnets becomes sufficient to equalize the two pulls, when the disk will stop, the pointer indicating the frequency on the scale.

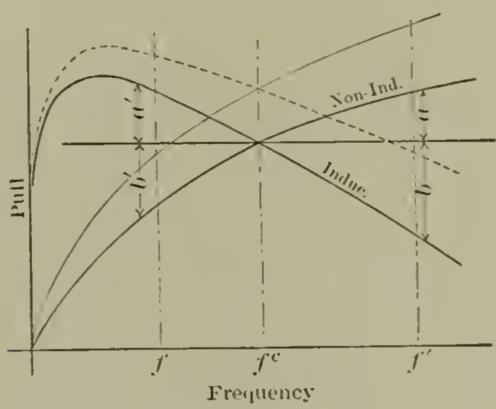


FIG. 3.

Referring to Fig. 3, it is seen that the pull on the two sides varies, as shown by the curves. To better explain the action of the meter, take the case of a similar arrangement of electro-magnets, with a circular disk controlled by a spring, whose zero torque is the scale center, then with a constant voltage, the difference in the ordinates of the curves at any frequency will be proportional to the deflection of the disk away from the center point, the point where the curves cross being the center position *Fc* on the scale. However, if the voltage increases, both of the curves shown above will increase their ordinates as shown in dotted lines, and therefore at all points except that at which the curves cross (or where the

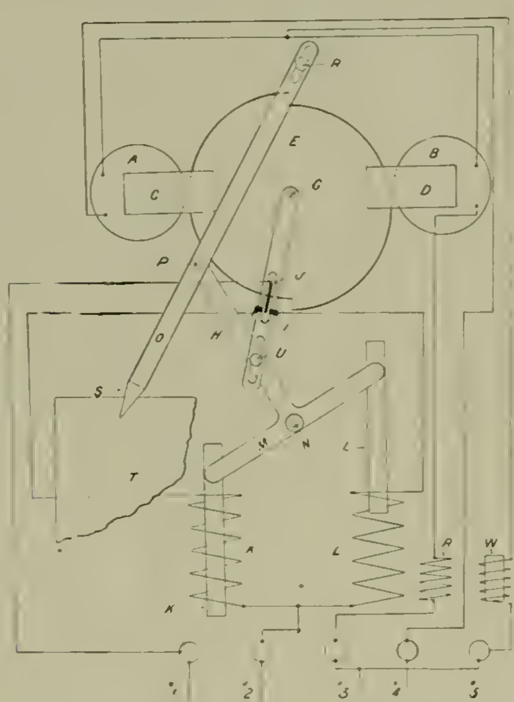


FIG. 4.—CONNECTIONS OF FREQUENCY METER—RECORDING TYPE.

spring torque is zero) the pull or deflection will increase and the meter will not be independent of voltage except at one point, *Fc*.

If, however, the controlling spring is removed and the disk is made eccentric, the disk will move as before stated until the pull on each side is the same; that is, the curves shown in diagram above are shifted so as to cross the ordinates corresponding to the frequency on the meter, and any change of voltage will affect the pull of each side equally, making the meter

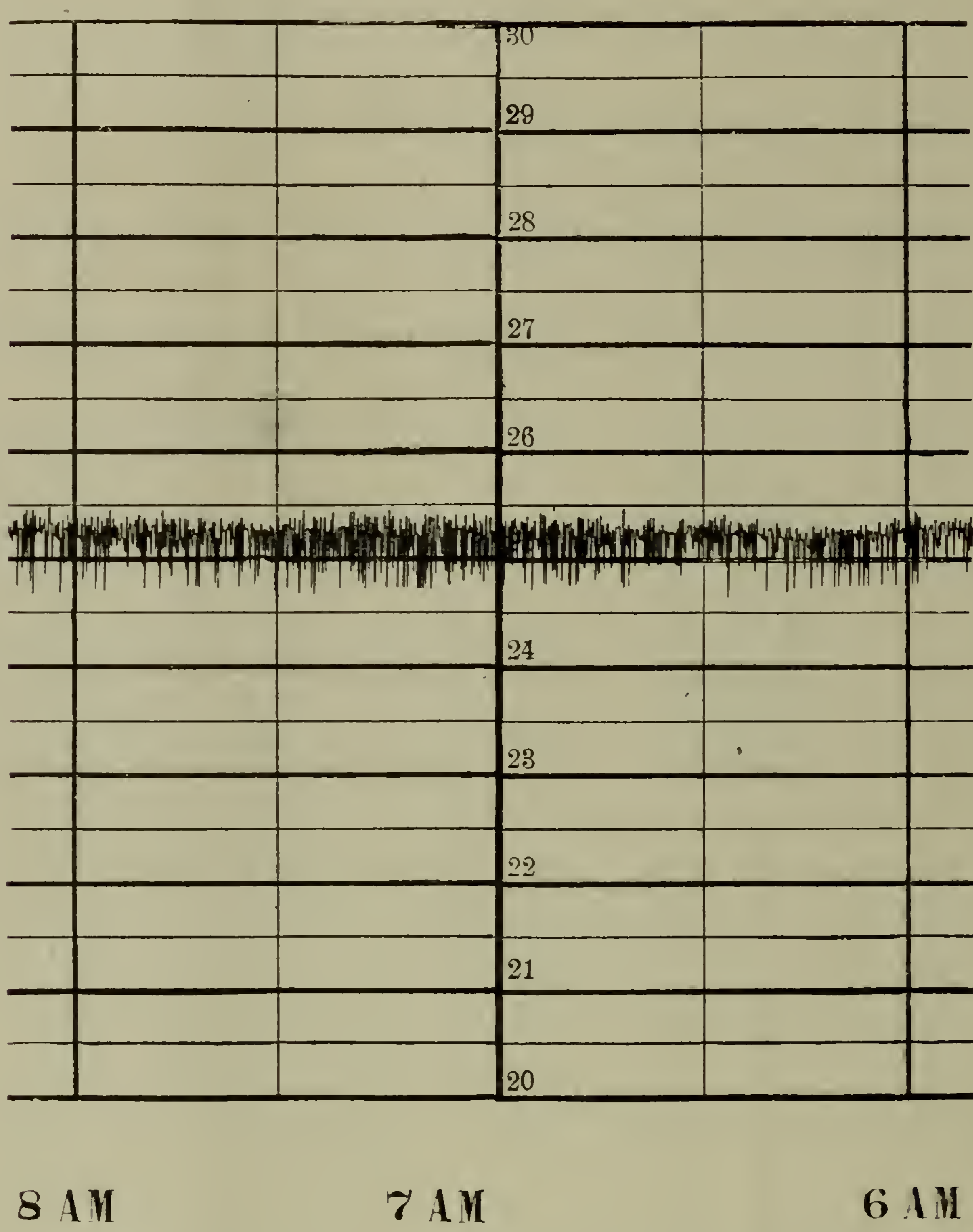


FIG. 5.—EXACT REPRODUCTION FROM SECTION OF PAPER—GRAPHIC RECORDING METER. FULL SIZE.

independent of the voltage. As actually constructed, the meters will be found to be practically independent of voltage from 75 to 125 volts. At each different frequency *f-f'*, the variation in the amount of the disk required within the air gaps to give a proportional scale, is shown by the lines *a-a'-b-b'* being drawn from the curve to the line of constant pull.

When it is desirable to secure a permanent record of the frequency maintained on a circuit, the use of a Graphic Recording Frequency Meter offers the most convenient method. This meter in common with the indicating form operates upon the "induction" principle. It differs, however, in mechanical construction, being of the "relay type," employing a suitable measuring element in conjunction with a pair of electro-magnets actuating the recording pen. There are in each meter three general elements: First, the meter; second, the pen actuating electro-magnets; third, the driving clock.

The general arrangement of the various elements is shown in Figs. 4 and 6, in which the measuring element is the same as that shown for the indicating meter, Figs. 1 and 2. The moving element, instead of actuating a pointer passing over a graduated scale, carries a light beam, at the lower end of which are mounted two insulated contacts, H and I, arranged to be engaged by the contact J attached to the disc.

The pen actuating element consists of a pair of powerful electro-magnets, K-L, differentially actuating a corresponding pair of pivotally mounted iron cores, K'-L'. The movement of these cores actuates the pen through a set of levers so arranged as to impart a straight line motion to the recording pen. The circuit of these electro-magnets is independent of that of the measuring element. The moving system of the measuring element, however, operates a differential set of contacts which alternately energize one or the other of the electro-magnets, depending upon the position of the measuring element movement.

The clock is of the electrically wound pendulum type, its function being to drive the record paper under the recording pen at a uniform predetermined rate, synchronous with the time markings on the record paper. Its electrically winding mechanism is operated from the same circuit as the pen actuating electro-magnets, and the driving motion is transmitted to the paper roll through a gear and pinion.

The record paper is 244 feet in length, being sufficient for two months' use at a two-inch per hour speed, or a proportionately shorter time at four or eight inches per hour. The rolls are six and one-quarter inches in width and are perforated at each outer edge by a line of holes which, engaging on projecting pins on the surface of the driving cylinder, insure a positively aligned speed under the recording pen.

The glass recording pen provides an ink reservoir of such capacity that one filling suffices for several months' use. To give maximum strength with minimum width of line the pen-point is drawn to a capillary tube of small bore and heavy strengthening walls.

As the torques exerted by the coils A-B tend to rotate the disk in the direction of the arrows, it will be seen that with equal torques on both elements the disk remains stationary and at normal frequency the contacts H and I do not touch either side of contact J. Any change in frequency will cause the internal electro-magnet contact to touch one of the outside contacts, and the connections are such that one of the electro-magnets will be energized, the particular electro-magnet being that which will tend to separate the two touching contacts in the direction of the other one. With the disk of the meter acting under the influence of a given applied frequency and tending to take up a definite position of equilibrium, contact will be made in such a way as will energize the electro-magnets and urge the pen mechanism ahead: this will continue until the disk has arrived in its position of equilibrium, when the pen mechanism will continue on an instant longer, sufficient to break contact and leave behind the disk mechanism upon which, the electro-magnet being dis-energized, it will come to a position of rest, the pen at this point being directly over the corresponding frequency. By means of the moving chart a continuous record is secured of the actual frequency variations.

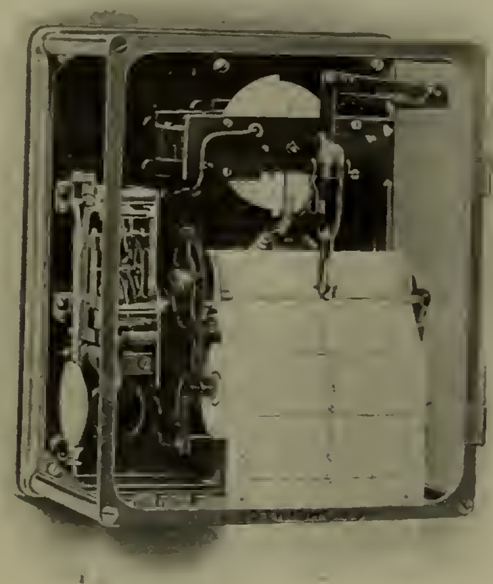


FIG. 6.—GRAPHIC RECORDING FREQUENCY METER.

Fig. 5 is a fac-simile reproduction of a chart obtained with such a meter installed in a large water-power plant. The extreme sensitiveness, as well as the satisfactory record, can easily be appreciated.

A Central Station Plan for the Wiring of Residences

BY HOWARD S. KNOWLTON

THE Edison Electric Illuminating Company of Boston has been perfecting a plan during the past two months whereby the wiring and rewiring of residences is to be executed at a reduced cost to the consumer, provided a suitable arrangement can be made with some responsible wiring contractor in the city. The plan has been adapted to the Boston conditions by working along the lines successfully tried out in the case of the Edison Electric Illuminating Company of Cleveland, Ohio, and the Boston company has had the services during this period of Mr. H. L. Snow, of the Cleveland organization, who was in close touch with the working out of the plan in the latter city from its inception. When the plan was started in Cleveland about eighteen months ago, two solicitors were at work on the residence wiring problem, and this fall there will be fifteen or twenty men detailed for this work alone. The force to be applied to the problem in Boston depends upon the arrangements and results which the company is able to secure, and cannot be definitely predicted at this writing.

The first cost of wiring an old residence is perhaps the most serious obstacle to the securing of a new customer for central station service. This always looks large to the prospective customer, who seldom loses sight of the fact that the contractor's profits are included, except in cases where the central station company does the wiring at cost, or possibly at a nominal percentage above the actual cost of labor and material. The Boston Edison Company does no wiring for customers or prospects, but in the plan discussed herein it is endeavoring to insure residences being wired at a considerable discount from the usual charges for such work. The plan is to turn all the residence wiring over to a single contractor in consideration of a reduction in price amounting to certainly 15 per cent. An arrangement is also made with a fixture house to supply consumers with fixtures at 20 per cent discount or over, in consideration of all this business being turned over to the single fixture house. Although the contractor's profits on each job is smaller than on scattered jobs, the certainty of the work and the profit, if properly handled, insure the arrangement as a good business proposition. The entire staff of solicitors, of which the Boston Edison Company has thirty, are interested in securing new customers, though, of course, the work is specialized into departments and classifications. From time to time the company adds to its list of prospects in various ways, the same general methods of securing residence customers as have been found acceptable in other work being used.

Recently the Boston Edison Company communicated with a large number of its customers asking for such comments and suggestions concerning the service as they might be pleased to offer. Among the many replies made were some valuable suggestions, but there were few criticisms or complaints of any character. This fact has been set forth in a letter which is sent to customers as occasion requires by Mr. R. S. Hale, general agent of the company. It further states that "we feel then permitted to assume that not only do you find the employment of electricity a distinct advantage, but you are pleased with the method of its supply. It has occurred to us that, this being true, you would be glad to have us convey to some of your friends and neighbors knowledge of new electrical methods, new appliances and improvements. Progress in the electrical field has been important, and some acquaintance with this progress cannot fail to be worth while. May we ask if you will send us the names of those whom you think should be interested?" The company encloses an addressed postal and with this letter and in this way secures a considerable number of prospects. Another successful method is for a solicitor to call upon customers and secure in person the names of friends and neighbors who may be interested in electrical applications and whose houses are not as yet wired. In this way a large list may be made up, and at the company's office this is verified and completed as to address and initials by the city directory.

The solicitor's arguments in favor of electric lighting against other means of illuminating residences are the same in case of residences to be wired first or rewired on account of the original installations having fallen behind the best practice as in working up business with new residences. In Boston much stress is laid on the economy due to the flexibility of the incandescent lamp and the saving in decorations over a five-year period. It is difficult to submit actual figures to prospects expressing the value of cleanliness in terms of money and health, but it is the experience of the company that when all the depreciation of decorations due to the products of gas combustion and oil burning is considered, electricity makes as good a financial showing as its rivals, if not better.

In addition to the standard Boston wire department and insurance requirements in wiring installations, the Boston Edison Company has a number of special requirements which must be met by customers, contractors, architects and engineers. All applications for either new or additional service must be made to the contract department and settled with this branch of the organization before any orders can be issued to the Department of Installations. Services are entered at the most convenient and suitable point and service cutout and switch provided by the company. In the underground city districts the service switch is located in accordance with the Wire Department and Insurance requirements, so that it is accessible from the street or back floor. A set-back charge of $1.50 per foot is made for each foot of underground service beyond two feet from the street line. In overhead districts no service charge is made unless additional poles and lines are required, and then charges are rendered in proportion to the number of poles and work necessary.

In the underground districts a service main of not less than No. 4 wire and at least two feet long is required from each service in order to facilitate the subsequent connection of branch cutouts, without interrupting the supply to others connected to the same service. The company issues a "street list" showing the different kinds of service available in different localities. It requires that meters be located in places accessible for reading and testing, free from vibration and swinging doors, and at least five feet from motor fields. Meters are not allowed in cellars unless they are reasonably dry and clear. Chambers and toilet closets are not allowed for meter locations, nor restaurant kitchens, unless at a good distance from ranges and sinks. In office and apartment buildings meters for the same floor are required to be located at one point in the corridor, and as near the point of service entrance as possible. Wooden meter boards are required, plumb and well secured, not over seven feet from the floor and with room enough to allow removing the covers and tipping the demand indicators. Whenever meter boards are mounted on brick or metal walls, they are required to be set out with air space back of them to insure against grounding meter frames either through moisture or screws. Meters are furnished by the company and remain its property. A meter cutout is provided ahead of each meter for its protection and in order that the meter may be connected and disconnected without interference with any other customer or meter which may be supplied from the same service. The company furnishes no fuses for new work except for its own service cutout. In the alternating current districts a ground wire is required for each service, unless supplied from underground secondary mains or from 550-volt three-phase lines. There are, of course, other requirements in connection with power service and the use of current on a large scale.

The company supplies each residence consumer with an eight-page wiring contract form, on which is made out the agreement between the consumer and the wiring contractor. This contract form contains the legal memorandum of agreement, the general specifications, schedule of work required, and the price list. The memorandum of agreement provides for the beginning of the work within two days after the contractor has been notified by the Edison Company that it will supply services to the customer, twelve days being allowed for the completion of the work. The payment called for is at the rate of 25 per cent. of the total sum on completion of the work and not less than 15 per cent. of the total sum per month thereafter. The specifications define the duties of the contractor and the general manner of carrying on the work, touching upon the insurance requirements and regulations of the Edison Company, responsibility for quality of work, extras and damages.

The schedule locates the outlets, receptacles, sockets and switches in each room, hall and portion of the house where lights are to be installed, and enables the total cost to be figured by the company on the basis of the price list without the need of a solicitor visiting the residence. The prices provide for the cost of wiring houses in process of building, old houses of wood and old houses of brick or stone.

Wooden Poles for Overhead Transmission

A SERIES of comprehensive tests were made recently by C. J. Wade on different forms of wooden pole structures for overhead transmission, the results being given in a paper presented before the British Institute of Electrical Engineers.

Tests are described with considerable detail, and "single," "A" pole and "H" types of pole are considered. The net result of the tests is to show the marked superiority of an "A" over a single pole, the "A" pole being shown to be at least 4½ times as strong as a single pole. Further tests showed that "A" poles were preferable to single poles both as regards economy and strength. To obtain the required strength in single poles, they would have to be of such a diameter as to be prohibitive in cost, and in some cases unobtainable.

Another series of tests showed that whereas a single pole would often deflect to a large extent before breaking, an "A" pole, so long as it held together at the top, would only deflect a few inches. The weakest point of an "A" pole is stated to be the top, where the stress due to windage and weight takes place. The two members of the pole—owing to their shape—have a tendency to slide and slip on each other when subjected to a load at the top. One member being in compression and the other under tension, that which is under tension elongates and forces itself away from the member in compression.

One advantage of wooden poles that the tests seem to have conclusively proved is their great flexibility and recuperative power after severe deflections from the perpendicular, caused by abnormal stresses. Such stresses are frequently caused during frosts by the contraction of the wires. Mr. Wade gave the life of creosoted wood poles as 50 years.

Electric Locomotives*

By H. L. KIRKER

I HAVE been asked in all seriousness if the magnetism of the electric locomotive increases the locomotive's grip on the track. I will answer in all seriousness that magnetism has nothing to do with it. The grip on the track, as in the case of the steam locomotive, depends on the weight on the drivers. As a matter of experience, we know that the adhesion under favorable conditions is such as to allow the engine to give a pull equal to 25 per cent. of the weight on the drivers. The average figure is 20 per cent. A locomotive then with 100 tons on the drivers could give a pull of 20 tons—possibly 25 tons—but if 30 tons were required to move the train, the engine would simply slip its drivers unless sand were used. The locomotives you are getting for the tunnel have their whole weight on the drivers. They weigh 125 tons, consequently are designed to give a draw-bar pull of 25 tons. In general the net weight of a locomotive can be taken as equal to five times the rated draw bar pull.

Your electric locomotive is designed to give 25 tons draw-bar pull because the train service demands it. The draw-bar pull for a given service is easily determined. In the present instance it depends on the weight of the train and the steepness of the grade up which the locomotive has to lift the train. The St. Clair Tunnel service involves 1000-ton trains and 2 per cent. grades. The Port Huron grade is 4914 feet long, say 5000 feet, and has a 2 per cent. rise. Two per cent. grade means that for every 100 feet advance there is 2 feet rise, consequently by the time the locomotive has travelled 5000 feet it has raised the train 100 feet. If the 1000-ton train were lifted straight up, the lifting force would be 1000 tons. On a level track there is no lifting force at all. Now a grade is something intermediate between the vertical and the level, so the lifting force on the 1000-ton train on a grade will be something between 1000 tons and zero. Since the grade is much nearer zero than vertical, the lifting force will be much nearer to zero than to 1000 tons. On the Port Huron grade, which is 2 per cent., it will be 2 per cent. of 1000 tons, or 20 tons. On a 1 per cent. grade it would be 10 tons for the same train. On a 3 per cent. grade it would be 30 tons. We see then that the locomotive must be able to exert at least a 20-ton draw-bar pull to meet the requirements of the Port Huron grade. The Sarnia grade also is 2 per cent. The lifting force is not the only one the locomotive must exert. The rolling friction must be taken care of. From experience we know that 10 pounds per ton should be added for rolling friction—this is independent of grade and speed within ordinary limits. Now, since our train weighs 1000 tons, we will have to add $10 \times 1000 = 10,000$ pounds, or 5 tons for rolling friction. The locomotive, therefore, must exert 25 tons draw-bar pull to get the 1000-ton train up the Port Huron or Sarnia grade—20 tons for lifting and 5 tons for rolling friction. Twenty-five tons draw-bar

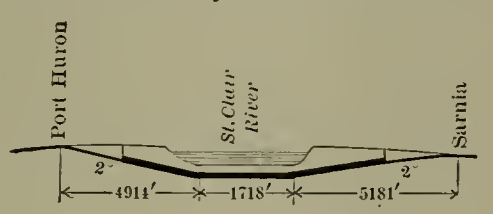


FIG. I.

pull means 5 times 25, or 125 tons weight on the drivers. We see then why the service requires 125 ton locomotives.

I stated that both the Port Huron and Sarnia grades are 2 per cent. Both grades are also, approximately, 5000 feet long. (See Fig. 1.) For our purpose we will assume them to be 5000 feet. Two per cent. of 5000 is 100, consequently every time a train goes through the tunnel it drops 100 feet and rises 100 feet. Now if there were no losses, a train could behave like a pendulum—the momentum it gathers going down one grade would carry it up the other. But there are losses, so there must be a locomotive to overcome them. Moreover, the trains sometimes stop on the grade; consequently, the locomotive must be able to work the train up the grade irrespective of momentum. We are therefore concerned in knowing the amount of work done getting the train up the grade. Now work is simply overcoming resistance through space. It is the product of the force by the space through which it is exerted. The force is measured in pounds. The space is measured in feet. The product of feet by pounds is called "foot-pounds." We measure work then in foot-pounds. The expression is $W = F\ S$. We have just seen that the lifting force exerted on a 1000-ton train on the Port Huron grade is 20 tons, or 40,000 pounds. Assuming the grade to be 5000 feet long, we see that the force of 40,000 pounds is exerted on the train through a space of 5000 feet, consequently, $40,000 \times 5000 = 200,000,000$ foot-pounds of work are done on the train. The same work would be done in lifting the 1000-ton train straight up the 100 feet, for a 1000-ton or 2,000,000-pound lifting force would have to be exerted through a distance of 100 feet. The product $(2,000,000 \times 100)$ is 200,000,000 foot-pounds, the same as before. If the grade were 1 per cent., it would have to be 10,000 feet long to rise 100 feet. The force required in this case would be only half as great, but since the space is twice as great the result in foot-pounds would be the same as before. As previously stated, force has to be exerted also in overcoming the rolling friction. We saw this force to be 10 pounds per ton, or 10,000 pounds for a 1000-ton train. Consequently the total force exerted on the 1000-ton train on a 2 per cent. grade is $40,000 + 10,000 = 50,000$ pounds. This total force exerted through a space of 5000 feet means $50,000 \times 5000 = 250,000,000$ foot-pounds of work. The 125-ton locomotive must be able to do this 250,000,000 foot-pounds of work. In addition, it must also do the work incident to getting its own weight of 125 tons up the grade. Two per cent. of 125 tons is 25 tons, or 5000 pounds, consequently, the work done by the locomotive lifting itself is $5000 \times 5000 = 25,000,000$ foot-pounds. To this must be added the work done overcoming the locomotive's rolling friction, which is $125 \times 10 \times 5000 = 6,250,000$ foot-pounds.

We have just seen that 250,000,000 foot-pounds of work are done getting the 1000-ton train up the grade. Now work has an exact signification. As indicated above, it means overcoming resistance through space. Speed does not enter into it at all. But power means the rate at which work is done. You know if a tunnel engine runs up the grade at the rate of 5 miles per hour each piston makes 70 strokes per minute. If it runs up at 10 miles

*An address delivered before The Grand Trunk R'y Literary and Scientific Institute of Port Huron, Mich.

per hour the pistons make twice as many strokes per minute, and the demand on the steam supply goes up accordingly. The steam consumption is proportional to the rate at which the work is done—it is proportional to the horse-power. Horse-power means work at the rate of 33,000 foot-pounds per minute. Now, if the locomotive exerted a draw-bar pull of 50,000 pounds while travelling at the rate of 10 miles per hour or 880 feet per minute, it would do 50,000 x 880=44,000,000 foot-pounds per minute. This, divided by 33,000, gives 1330 horse-power—the rate at which the locomotive works when hauling a 1000-ton train up a 2 per cent. grade at 10 miles per hour. At 5 miles per hour the rate would be 665 horse-power. At 20 miles per hour the rate would be 2660 horse-power. This does not include the work done by the locomotive on itself, which is 12.5 per cent. as much as it does on the train.

I have just pointed out that the net weight of the locomotive settles the adhesion; that the adhesion limits the draw-bar pull; that the weight of the train, the rolling friction and the per cent. of grade determine what draw-bar pull the locomotive must be able to give; and that the draw-bar pull and the speed give the rate of work, or the horse-power that the locomotive must be able to develop. We have found the horse-power required for our train on the Port Huron grade. Now let us see what horse-power will be required to run the same train at 40 miles per hour on a level track. Forty miles per hour means 3520 feet per minute. Assume that 10 pounds per ton, or 10,000 pounds total for the 1000-ton train, to be the force necessary to overcome the rolling friction and windage. The draw-bar pull will, therefore, have to be 10,000 pounds. It will be exerted through 3520 feet per minute. The work done on the train then will be 10,000 x 3520 = 35,200,000 foot-pounds per minute. This divided by 33,000 gives 1066 horse-power—the rate at which the locomotive works to keep the 1000-ton train moving at 40 miles per hour on the level track. This does not include the horse-power expended by the locomotive itself. The locomotive weighs 125 tons, or 12½ per cent. of 1000, consequently 12½ per cent. additional power (133 horse-power) will have to be expended by the locomotive on itself.

We have seen that it is easy to figure the horse-power required to run the train up grade, and to figure the horse-power required to run the train on a level track. The next thing we want to know is the power required to start the train on a level track. This power will depend, of course, on the force exerted and the distance through which it is exerted per minute. Force is measured by the result it produces. One of the results it produces is a change in the velocity of the mass on which it acts. If the draw-bar pull is such as to give the train a velocity of 60 miles per hour in one minute, or 60 seconds, we see that the draw-bar pull adds one mile per hour to the speed every second during the 60 seconds it is exerted. This means an increase in velocity at the rate of one mile per hour per second. Rate of change of velocity is for short called acceleration. The draw-par pull exerted in bringing the train up to speed is measured then by the acceleration it produces. The expression is simply, force equals mass multiplied by acceleration, or F=M A. The force is measured in pounds, the mass is one thirty-second of the weight in pounds, and the acceleration is measured in feet per second. Mass has an exact meaning, but for our present purpose it will suffice to say that mass can be found by dividing the weight in pounds by 32. We will assume that we want to bring our 1000-ton train up to speed of 30 miles per hour in one minute. This means that one-half mile per hour is added to the velocity every second during the 60 seconds the train is getting up to speed. One-half mile per hour means 0.735 feet per second. Consequently, 0.735 feet are added to the velocity each second for 60 seconds. Our acceleration, therefore, is 0.735 feet. Our train weighs 1000 tons, or 2,000,000 pounds, consequently, its mass, which is one thirty-second of this, is 62,500. The product of the mass by the acceleration (62,500 x 0.735=45,900) equals, as stated, the force exerted—the draw-bar pull—during the minute of acceleration. Now that we have the draw-bar pull, our next step is to determine the space travelled during this minute of acceleration. It is easily found. At the beginning of the minute the velocity was zero, at the end it is 30 miles per hour; the average, therefore, is 15 miles per hour, or 1320 feet per minute. Consequently, the draw-bar pull of 45,900 pounds is exerted through the space of 1320 feet for one minute. The work done per minute is the product 45,900 x 1320, and equals, say, 60,600,000 foot-pounds. This divided by 33,000 gives, approximately, 2100, the horse-power required to bring a 1000-ton train up to a speed of 30 miles per hour in one minute on a level track. To this must be added, of course, 12½ per cent. (262.5 horse-power) — the horse-power expended by the 125-ton locomotive on itself.

I just stated that 60,600,000 foot-pounds would be expended on a 1000-ton train in bringing it up from a stand still to a speed of 30 miles per hour in one minute on a level track. This energy is stored in the train. The conditions are similar to the case of the fly-wheel. Once in motion the fly-wheel continues to revolve after the power is shut off until the stored energy is used up. Our 1000-ton train with 60,600,000 foot-pounds stored in it will continue to move after the power is cut off until these stored foot-pounds are used up. They can be used up by the brakes, or by the rolling friction of the train, or by running the train up grade. It is an easy matter to figure the stored energy in a moving train if we know the speed and weight of the train. The stored energy is equal to one-half the product of the mass of the train multiplied by the square of the velocity. The expression is $W=\frac{1}{2} M V^2$. Here W means foot-pounds, M means mass, which, as stated before, is one thirty-second of the weight in pounds, and V means velocity in feet per second. The mass of the 1000-ton train is 62,500. The velocity here is 30 miles per hour, or 44.1 feet per second. The foot-pounds of stored energy then equal ½ x 62,500 x 44.1 x 44.1, or 60,600,000 foot-pounds, which of course is the nergy required to bring the 1000-ton train up to a speed of 30 miles per hour. This figure does not include the energy stored in the locomotive. We find the energy stored in a 125-ton locomotive moving at the rate of 30 miles per hour in the same way that we find it for a 1000-ton train that the locomotive hauls. You will note that time does not enter into the formula for stored energy. The elements are mass and velocity, consequently, the stored energy will be the same whether one minute or ten minutes be taken, to give the mass a velocity of 30 miles per hour. You will note further that the stored energy increases as the square of the velocity. Consequently, if the 1000 tons are moving at the rate of 60 miles per hour instead of 30 the stored energy is four times as great. With four times the stored energy, four times the former braking would have to be applied, or four times the former distance up grade would be run in bringing the train to a stand-still.

If the stored energy is used up in the brakes it is wasted as heat. The heating due to the brake friction may be sufficient to make sparks fly. The heat can be measured. Every 778 foot-pounds equals a heat unit—the amount of heat required to raise a pound of water one degree Fahrenheit. Likewise, every heat unit transformed into motion can do 778 foot-pounds of work. Consequently, the heat that was transferred into train motion can be given out again in rolling friction and brake friction. The heat was originally stored in the coal. We know from experiment that a pound of average coal contains 12,000 heat units. We also know from experiment that, as stated above, one heat unit can do 778 foot-pounds of work. We see then that there should be a definite ratio between the work done by a steam locomotive and the coal the locomotive burns. This being the case we can, if we know the efficiency of the locomotive, figure the amount of coal required by the locomotive to do its work. However, I am now calling your attention not to locomotive efficiency, but to the fact that the steam locomotive is a heat engine. This particular heat engine is based on the expansive property of steam. It is a sort of a power plant on wheels. Its functions are simple. Its actions are easily understood and, as we have just seen, is performancee is a matter of easy calculation.

You probably wonder what all this has to do with electric locomotives. Well, the answer is not far to seek. We have seen that the net weight of the locomotive must be five times its rated draw-bar pull, that the draw-bar pull is settled by the service conditions—weight of train, per cent. of grade, acceleration, speed, rolling friction. We have also seen that it is easy to figure the horse-power required for the various service conditions, and that our measure is foot-pounds—which is also the measure for the stored energy of the moving train and for the heat units in the coal pile. Then we saw that the transformation of heat into the forces exerted by the steam locomotive depends upon the expansive property of steam. Now the electric locomotive must be able to exert the same forces. So far as the results are concerned then, the two machines are similar. This similarity gives us a common ground, a basis for the comparison of the two types of locomotives. I shall deal only with the essential difference between the two machines, which is this—the force exerted by the steam locomotive depends upon the expansive property of steam, while the force exerted by the electric locomotive depends upon the magnetic properties of the electric current. You undoubtedly have a simple mental picture of piston moved by steam. I want to give you a simple mental picture of a wire moved by an electric current. Once you can satisfy yourself that a wire carrying a current in a magnetic field is forced across that field, you can satisfy yourself as to the workings of the electric locomotive.

(TO BE CONTINUED.)

Advantages of Mechanical Draft

THE advantages claimed for the induced system of mechanical draft are:

1. Low first cost. For isolated plants where the nearness to neighboring buildings does not make it necessary to erect a tall chimney in order to discharge the gases at a great height above the ground, the cost of an induced draft system will always be less than the cost of a substantial chimney unless the plant be small. And usually the cost will be less than the cost of the mechanical equipment and chimney necessary for a system of closed ash-pit, forced draft.

2. No necessity of a chimney. An induced draft plant never needs a chimney to aid in producing the draft, and whenever a chimney is used with one it is made necessary by other considerations than the draft. When anything more than a short stack is required, the cost of the additional chimney should not be charged as a disadvantage against the mechanical draft plant, although it must, of course, be included in the total cost of the draft producing apparatus and may often make the decision of how to produce the required draft adverse to the induced system.

3. Control of draft. Since the draft is due entirely to the action of the fan and increases and decreases as the fan is run faster or slower, it is evident that it is entirely under control and can be varied at will to suit the requirements of the instant. With a chimney a hot fire means a high temperature of the escaping gases and therefore a high draft, and a low fire means a low draft; while with an induced draft system the draft may be made low with a hot fire or high with a low fire, and is always independent of everything except the speed of the fan.

4. Uniform combustion. The combustion in a furnace equipped with an induced system of mechanical draft is just as uniform over the whole surface of the grate as it is with ordinary chimney draft. There is no burning through of the fire in spots as there is likely to be with the closed ash-pit system of forced draft, especially with high drafts.

5. Leakage inward. This makes it easier for the fireman to tend to the furnace and ash-pit, avoids the trouble due to blowing hot gases or air, or cinders or ashes into the fire-room, even when the furnace or ash-pit doors are open; and further, there is not the same tendency to increase the deterioration of the boiler or its setting that there is with the closed ash-pit system of forced draft. The leakage is exactly the same as with ordinary chimney draft and produces no more bad effects for the same intensity of draft.

6. Adaptability to use with economizers. This is one of the strong points in favor of the induced draft system, as cooling the gases after they leave the boiler results in an increase in the number of pounds of water evaporated per pound of coal, and, therefore, an economy in the operation of the boiler plant without affecting the draft. It is possible to do any of three things when an economizer is used in connection with an induced draft system:

(*a*) Reduce the speed of the fan until it gives only the draft necessary to burn the required amount of coal. This results in using less steam to run the fan and this saving in steam, together with the saving due entirely to the economizer, will usually result in a marked economy in the operation of the plant.

(*b*) Run the fan at the same speed and burn a larger quantity of coal of a cheaper grade, so as to evaporate the same amount of water per hour with the economizer that was evaporated before. This almost invariably results in a marked reduction in the coal bill, and, therefore, since other things remain the same, in an economy in the operation of the plant.

(*c*) Run the fan at the same speed but burn a larger quantity of the same coal than was used before the introduction of the economizer. This results in an increase in the coal bill, with an increase in the steam capacity of the plant while keeping the fixed charges, such as wages and cost of operation of the fan, the same. The increase in the capacity is always greater than the increase in the coal bill; and since the fixed charges against the plant are increased only by the interest on the first cost, depreciation, repairs and operating expenses of the economizers, the cost of making a pound of steam is materially reduced.—*From "Mechanical Draft," by J. H. Kinealy.*

Shoemaking Machinery

THE same general rules followed in the application of motors to laundry and woodworking machinery apply to the problem confronting the power salesman who would equip shoemaking machinery with motor drive. Shoe shops have individual drive and group drive, there being good examples of both. Most shops have started in on the group plan, applying a motor to drive a whole floor, or a large section of a floor. This has been followed by the evolutionary scheme of gradually cutting up the group into a number of smaller groups and finally into individual units.

Shoe machinery in general favors the limited group type, because the amount of power required in each operation is small and the work is of the rapid intermittent class. One 5-horse-power motor will carry several times as many machines that a total of 5 horse-power of smaller motors will carry, if the individual drive were adopted. The group drive in this case, therefore, tends to low initial cost and good working results.

Both direct and alternating current motors have been used for this kind of work. When the funds available for the installation have permitted the individual drive, the motors have been usually mounted upon the machines. But if not, then floor, wall or ceiling mounting has been used, depending on the conditions.

The following list is based on the results obtained by installing motors in some of the largest factories in the country.

NAME OF MACHINE.	Motor H. P.
Buffing machine	½
Double buffer and blower	½
Buffer and grinder	½
Beating out machine	¼
Channeller	1/15
Dinker	1
Beam dinker	2
Laster, hand	½
Moulder	
Twin	1
Bus counter	¾
Rounder, sole	1
Roller	2
Setters, edge	1
Splitter	
Special	¾
Stanley leather	¾
Common sense	¾
Stitch separator	1/6
Stitcher	¾
Shirers	
Fifiel	½
Smith stiffening	1/6
Small	½
Scorer	1/6
Shaver, heel	2
Sole layer	2
Trimmer	
Sole	2
Heel	2
Turner	
Channel lip	1/6
Welt machine	½
Wire fastener	½

Shoe machines to do the same class of work require about the same amount of power, whether manufactured by one company or another.

In grouping the above it is well to confine the sizes of motors to as few in number as possible. Most of these can be driven from the 3-horse-power, 5-horse-power and 7-horse-power size motors. By having many motors of a similar size changes, quick repairs and number of spare parts to be carried are best provided for.

Shoe shops are now established over the whole country, the western march of civilization favoring their location West as well as East. The old cobbler is fast giving way to a central repair shop in each of the larger cities, a shop equipped with shoemaking machinery is patronized by the retail stores of all kinds, irrespective of their commercial differences in business.

Electrical Show at Madison Square Garden, Sept. 30 to Oct. 9, 1907

THE opening of the Electrical Show at Madison Square Garden is announced by President George F. Parker for September 30, 1907. All the larger interests in the electrical trade are taking a keen interest in this exhibition, and the management expect to put forth their best efforts to interest the trade and interest laymen in the latest and most up-to-date electrical appliances, inventions and devices.

At the Electrical Show will be exhibited everything from a miniature one-eighth of a candle-power incandescent lamp to a ten-ton dynamo. The exhibition includes every appliance for office or home in which electricity is used. Nowadays the discomforts of culinary labors are as nothing compared to what they were in the past, owing to the agency of the great servant of the world, electricity. It is the object of the managers of the Electrical Show to give an impetus to delving into the mysteries of electricity and to advance the world toward what might be described as the commercial and domestic millenium.

Madison Square Garden will be laid out on a plan that is unique. There will be three avenues, Edison Ave., Westinghouse Ave. and Franklin Ave., running from east to west with three cross streets running from north to south. The interior will contain 300,000 electric lights. At each corner goose-neck lamp-posts will mark the intersections, and a magnificent arch in a blaze of incandescence is to mark the main entrance. Every exhibit will be fitted up with all kinds of wireless appliances connecting with stations now in vogue.

The New York Edison Company, one of the largest exhibitors, has in mind a plan for the exterior decoration of the Madison Square tower. It is to be one solid bank of lights.

German and French electrical merchants and inventors have signified their intention of exhibiting at the Electrical Show and every prominent firm in America will have floor space there. Every invention known will have special demonstrators to teach buyers, tradesmen, electricians and the world in general all that is known concerning electricity.

"We will have on exhibition at the Electrical Show at Madison Square Garden everything electrical," said President Parker; "the modern motors and appliances of automobiles, of course, we will have, but no complete machines. It is our intention to instruct the out-of-town trade or any one interested, and every one who has attained the age of reason is interested in electricity and its uses and mechanical appliances up to date. The show extends from September 30th to October 9th."

The big Electrical Show, which will be an epoch among the shows at Madison Square Garden, will have besides a wondrous floor arrangement and remarkable decorations a novelty in the sharing of the box-office receipts to the exhibitors with the management. Fifty per cent. of the receipts will be divided among the exhibitors pro rata. The following is the basis of the profit-sharing plan:

Each exhibitor is entitled to one ticket for admission for each dollar of rental paid for space; additional tickets may be purchased in lots of one hundred at 12½ cents each; as half of this will be returned to exhibitors in proportion to their rental, the net price thereupon becomes 6¼ cents each.

One of the exhibits to be seen at Madison Square Garden during the Electrical Show will be a 2,000,000-candle-power arc lamp elevated in a specially constructed tower in the center of the interior. Recently Mr. Scott, of the Scott Electric Company, inventor of the light, made a successful test with a 300,000-candle-power arc lamp in front of the New York Theater, on Broadway, and thereupon decided that the power could be raised to 2,000,000.

The wonders of lighting are to be exhibited in their fullest at the Electrical Show, and this 2,000,000-candle-power arc lamp, which the inventor claims will radiate like the noon sun, will be one of the most convincing evidences of the march of electrical progress.

The Fuel-Testing Plant of the United States Geological Survey near Norfolk, Virginia

By C. T. WILKINSON

THE fuel-testing work of the United States Geological Survey should be followed with close interest by all engineers, not only because it is important to all power consumers, but in this branch of the government work, because it is undertaken to point out new paths for the development of the natural resources of the country by locating, classifying and testing all kinds of available fuel.

In Europe, where the fuel resources are now fully known, there has been no need for so powerful an organization as that which is now rapidly making the resources of this country as well known to the public as that of the older European countries.

at 9000-900 revolutions; also three Green Fuel Economizer Company's induced draft fans.

The method of work planned for this section is to be slightly changed, so that instead of testing a great number of coals, more tests will be made of the same coal, different sizes and different methods of stoking or feeding, etc., being employed with the object of determining the most economical performance under different rates of combustion and the best ratios of grate and heating surfaces.

The B. & W. boiler will be placed beside the two Heine boilers which have been brought from St. Louis, all three having been provided with in-

An additional alternating current turbo-generator set may be installed as indicated (Fig. 1) to supply power for external and exhibition purposes.

The steam engineering division, which has now practically succeeded in isolating the performance of the boiler from that of the combined performance of the boiler and furnace, will carry on further tests with the object of still further determining the performance and efficiency of the furnace alone.

The apparatus in the producer-gas section is arranged as shown in Fig. 1. The gas, immediately on entering the building, passes through the meter and thence to the Westinghouse gas en-

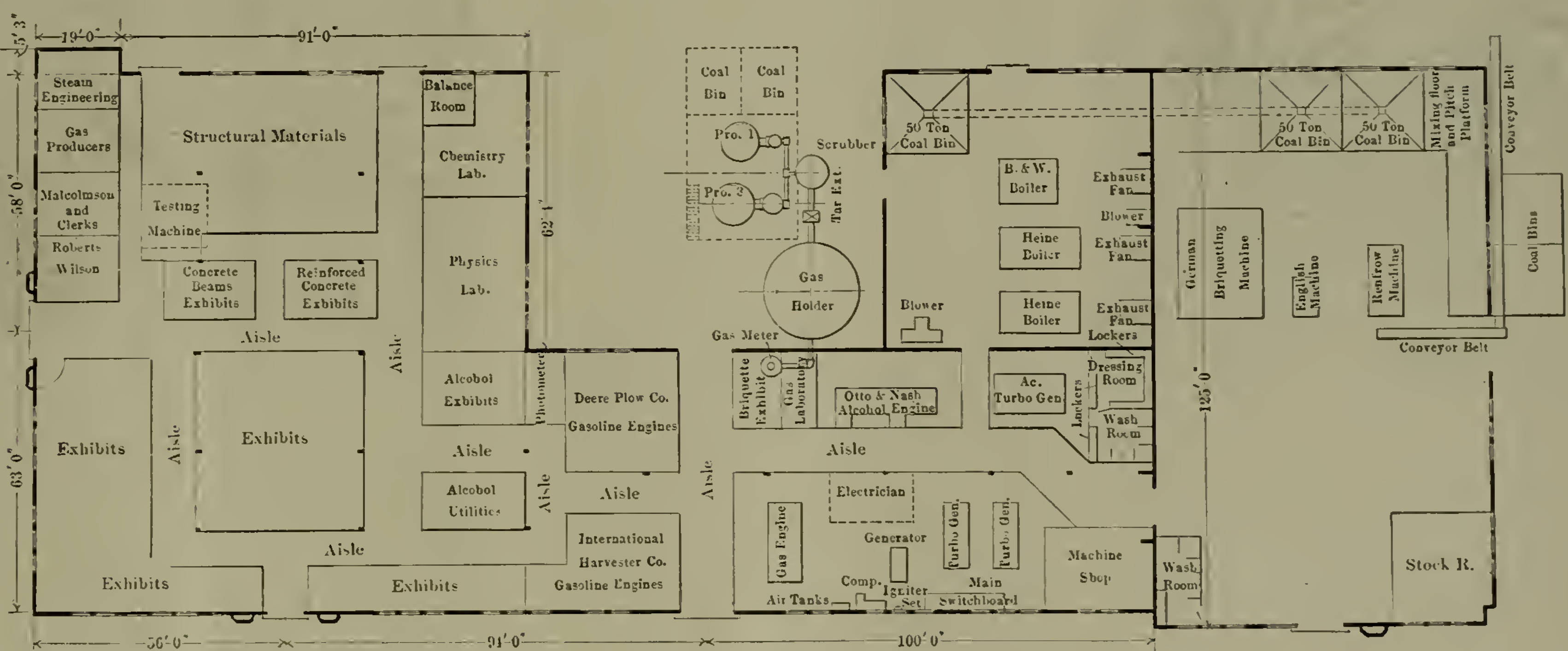


FIG. 1.—PLAN SHOWING LOCATION OF BOILERS, GAS PRODUCERS AND ENGINES.

Accurately compiled results of the more recent work of this branch will soon be published, and the following particulars of the plant in Virginia will doubtless be of interest.

The plan illustrating the location of the boilers, gas producers and engines is shown by Fig. 1.

New apparatus has been added in the steam engineering division as follows: A 250-horse-power Babcock & Wilcox boiler, with superheater, provided with a Roney stoker (Fig. 2); a Jones underfeed stoker with fan, added to one of the old Heine boilers; two direct current DeLaval turbine sets (Fig. 3), rated 300 horse-power

duced draft apparatus in order to get a wide range of capacity. The Heine boiler provided with the Jones stoker has the usual arrangement for forced draft. The B. & W. boiler was inserted partly to enable tests to be made of the same fuel with different types of boilers. It serves to represent the types employing a perpendicular flow of the gases through the tubes, the parallel flow types being represented by the Heine boilers. The Heine boilers have been rebaffled or partitioned in such manner as to practically double their length by compelling all the heated gases to pass along the entire length of the tubes twice.

gine transferred from the St. Louis plant, shown in Fig. 4. Some slight changes have been made in this apparatus. For instance, producer No. 7 has been provided with a water seal at the base to permit the ashes to be removed without admitting air, and several holes have been bored at different heights, to be used for extracting samples of the gas. The purifying apparatus used at St. Louis has been removed, (this, it will be remembered, consisted of the usual chamber containing iron filings and wood shavings), since experience indicates that the danger from impurities has been considerably exaggerated.

A special steam pipe has been provided to insure a steady water pressure, since the pressure of the supply mains fluctuates considerably.

The gas engine is belted to a 200-kw. Bullock generator brought from

FIG. 2.—INTERIOR OF THE BOILER HOUSE.

St. Louis, which serves to drive the motors for the apparatus in the building, the machine shop, the briquetting plant, the elevators and the conveyor. Any additional load required is ob-

FIG. 3.—DE LAVAL TURBO-GENERATOR SET DIRECT CURRENT.

tained by means of a water-box resistance, which can be regulated by the switchboard attendant so as to maintain a steady full load value.

The plans of this section include the following determinations:

The proper length for a test run, the effect of the size of the coal, the best depth of the fuel bed, the effects of rapid load variations, the maximum returns from different fuels, and the response of a producer plant to sudden demands for power.

A new work of great importance is being undertaken by the alcohol and gasolene engine section. Its equipment includes two 15-horse-power, 250 r. p. m. Otto gas engines; two 15-horse-power Nash Company's engines, one 2-horse-power International Harvester Company's engine, and two John Deere engines rated at 14 and 18 horse-power respectively.

Experiments will be made covering the whole range of this field, but for the present the work will be confined chiefly to examinations of different carburetters with the object of showing the lines along which a more efficient method of vaporization may be obtained. The other more prominent work is the examination of the kinds of fuels available, with special reference to gasoline versus alcohol, and an investigation of the use of kerosene as fuel for this class of engines, an investigation necessitated by the increasing demand of gasoline and the limited supply available.

The study of the destructive distillation of the coal and its combustion in gas producers, coke ovens and furnaces, especially from the standpoint of physical chemistry, will be undertaken by several divisions.

The briquetting division, which occupies the large room at the end of the building, is putting down one large additional German briquetting machine, while the previous apparatus of English and American manufacture that was used at St. Louis is installed in the same room. The work of this division will be chiefly the manufacture of briquetts from various run-of-mine coals of the Eastern fields, which will be tested on war vessels under the direction of the steam engineering division.

The further fuel-testing work of the

FIG. 4.—235 H.-P. WESTINGHOUSE GAS ENGINE —TRANSPORTED FROM ST. LOUIS.

Geological Survey includes tests dealing with the spontaneous combustion of stored coals, in which an effort will be made to simplify the methods for its preventation; while a corps of

FIG. 5.—BULLOCK GENERATOR, TO BE BELT-DRIVEN FROM WESTINGHOUSE GAS ENGINE.

specialists will be detailed to investigate closely the whole subject of explosions in coal mines with a view to eliminating danger from this source.

The Power Plant of the Grenoble-Chapareillan Electric Railway

By FRANK C. PERKINS

IT is estimated that the amount of power available in the Alps Mountains along the Swiss frontier is about five million horse-power. The water-power now utilized, it is stated, is only about one-tenth of this amount or half a million horse-power, but even this development has had a great influence on the French industry along the border, as the cost of coal is very high. A large amount of the coal used in France is imported, and wherever a water power is available the cost of operation of an electric railway, power transmission or lighting plant is greatly reduced by the installation of a hydro-electric plant.

The electric railway from Chapareillan to Grenoble, France, is 43 kilometers long and is particularly interesting from the fact that it is operated on the three-wire system with a pressure of 1200 volts between the outside conductors.

THE POWER PLANT.

The accompanying illustrations show the exterior and interior of the generating plant supplying current for this railway. It was installed by Schneider Et Cie, of Creusot, France. The Berges power-house supplies 200 horse-power for the operation of a paper factory in large and small units and two generators of 200 kw. and 300 kw. respectively are utilized for supplying electric light for the Gresibaudan Valley. Three electric generator sets have been provided for operating the electric railway above referred to, each having a capacity of 250 kw.

The turbines operate under a head of 470 meters and have a speed of 350 revolutions per minute. The turbines are of the Brenier-Neyret type and are directly coupled to single phase alternators of the Labour type built by the Societe l'Eclairage Electrique. These machines generate a current of 125 volts with a frequency of 50 cycles per second. Six one hundred kw. transformers are utilized for raising the pressure from 125 volts to 12,000 volts. The alternating current switchboard consists of three panels, one of which is utilized for coupling the alternators. One of the transmission lines runs south of the power plant connecting with the Grenoble-Chapareillan Railway, about 20 kilometers from the station, as well as at various points along the line, lighting step down transformers ranging from 7 kw. to 50 kw. capacity are employed lowering the pressure of the transmission line to 120 volts for the various villages along the line.

The generating station supplying current for the Grenoble-Chapareillan Railway is located near the Burgess station and is owned by the railway company, but the power is purchased from Mr. Aristride Berges at 100 francs per horse-power per year, with a minimum rate according to this contract price of 25,000 francs. As this is a water-meter rate, the actual cost per kilowatt-hour would be .025 francs or about one-half cent with an efficiency of 80 per cent for the electrical generators.

The accompanying interior illustration shows in the background three generator groups consisting of Thury Electrical Generators of the six pole 600 volt type, each supplying 417 amperes and directly coupled to a Brenier-Neyret turbine operating at a speed of 325 revolutions per minute. One of these direct current sets is kept for use in case of an emergency, and the other two are operated in series. The common terminal is connected to the neutral busbar of the switchboard while one outside terminal of the generators is connected to the positive busbar of the switchboard and the other terminal to the negative of the switchboard. The shunt field current is controlled by an automatic regulator and rheostat of the Thury system and the machines are compounded to give a constant pressure of 600 volts.

The railway is divided into three sections and on each feeder a series generator or booster is provided to keep the voltage up to the proper point. On the Grenoble section the

INTERIOR OF PLANT.

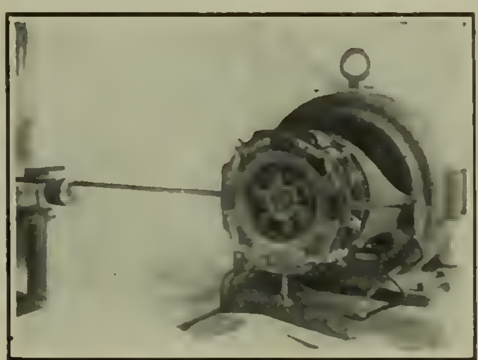
boosters have a capacity of 80 horse-power, and those of the Chapareillan section 56 horse-power, while the machines of the Drogeaux section have an output of 40 horse-power, being compounded for constant speed. As will be noted by the illustration, one electric motor in the center is directly connected by Rafford couplings to the two boosters on the two wires of the same section.

The neutral busbar at the switchboard of the generating station is connected by a cable about 3 kilometers long to the electric railway service rails, the cable having a cross section of 125 square millimeters. Each of the three sections may be isolated when desired and a feeder is connected from the positive busbar and the negative busbar of the power-house switchboard to a central point on the two wires, a positive and a negative feeder being thus connected with each section, which are 5 kilometers, 13.5 kilometers, and 23 kilometers in length. The fall of pressure on the Drogeaux, Chapareillan and Grenoble sections is 150 volts, 225 volts, and 360 volts, the sections of the feeders being 64 square millimeters, 125 square millimeters, and 90 square millimeters respectively. The insulators are of the double petticoat type and the line is mounted on metal poles. Two copper wires are installed along the whole length of the track 70 centimeters apart, each having a diameter of 9 millimeters, the pressure between these two conductors being 1200 volts.

The motor cars are provided with two electric motors, each having a capacity of 35 horse-power, a 4-pole Thury motor being used on each of the two axles. Three motor cars are employed for each train, which has a seating capacity for about 100 passengers. Each car weighs about 18,000 pounds, making the total weight of the train about 56,000 pounds. The power plant is capable of operating about 10 of these trains without difficulty, even though part of the trains are on maximum grades of about 4 per cent. The turbines in the power-house have an efficiency of 94 per cent. at full load.

Testing Electric Motors by Eddy Current Brakes

THE accompanying illustration shows the construction of a new English eddy current dynamometer brake of 10-horse-power capacity on a motor operating at a speed of 900 revolutions per minute.



MOTOR WITH EDDY CURRENT DYNAMOMETER BRAKE.

In order to test a motor for efficiency and suitable rating it is necessary that the motor should be subjected to a measured load of the desired amount for long or short periods, and it is desirable that a steady maintenance of the load and an accurate measurement be obtained without affecting the conditions under which the electric motor is working.

There are a number of methods utilized for absorbing and measuring the energy of a motor. The energy dissipated by the electrical methods of testing motors may be by eddy currents only, or by eddy currents and hysteresis with fixed field or revolving field and with air cooled or water cooled testing brakes.

It is maintained by many engineers that eddy current brakes have many advantages over rope or band types for electric motor testing, as there is an absence of wear and uniformity of load, while the heat produced in the energy absorbing element is not conducted to the bearing, with the added convenience of adjustment to exact balance and great sensitiveness.

The brake shown in the accompanying illustration is of the eddy current type and was designed to be mounted on the motor shaft in place of the ordinary pulley, dispensing entirely with separate frame or bearing. It was designed for the Electrical Laboratory of the University of Birmingham, England. The revolving system carries the fixed portion of the brake, and although there is friction at the brushes, this small load is duly represented as torque on the brake lever, the same applying to the air friction.

There are two copper disks used, insuring electrical as well as mechanical symmetry, as one revolves on either side of the magnetizing coils and this renders it entirely astatic, at the same time doubling the capacity of the brake for a given diameter. The brake is mounted on the spindle of the electric motor to be tested, and the pressure on the motor bearing may be adjusted to a nicety. The upward pull gives rise to no twisting moment as the brake is provided with a link suspension attached to a spring balance, the latter being carrier by the hooks of the crane or the blocks used for the testing bed. The pressure on the bearing may be any value desired, or may be reduced to zero by means of the lifting gear, and it is maintained that by this unique eddy current brake the bearing friction of motors may be ascertained with a greater degree of accuracy than with any other method.

It is stated that the brake may be carried on the motor spindle without suspension for ordinary testing, as its weight is less than the normal belt pull. The theory of the Eddy current brake, it may be noted, is in many respects the same as that of the induction motor, although it is simplified by the fact that inductance is absent from the motor. It is stated that one of the characteristics of this brake is the steady manner in which the lever floats after the magnetizing current has been adjusted, and this is said to be due to the fact that the center of gravity of the sliding weights is slightly below the center line. By using properly suspended flexible conductors, the magnet coils are supplied with current without difficulty, without the use of mercury cups. Electric motors may be tested for starting torque by locking the revolving disks to the fixed part of this Eddy current brake.

Combined Ice and Electric Plants

SOME interesting facts were given by R. E. Lee concerning the operation of a combined ice and electric plant in a paper read before the Iowa Electrical Association. The plant is located in Clarinda, Iowa, the ice manufacturing part being of 15-ton capacity (based on ice making and not refrigerating capacity), and the cost of this plant, including additional real estate purchased, but not including boilers, is about $1,000 per ton, or a total of $15,000. The life of the plant has been estimated at 15 years, which means that approximately $1,000 per annum must be set aside to replace equipment. It is self-evident that the more tons of ice manufactured per annum, the less per ton will have to be added for depreciation in making up one's cost per ton manufactured.

Under ordinarily favorable conditions, the ice season does not last over six months, which means that a 15-ton plant would only turn out 2700 tons of ice running full capacity. But, assuming that 300 tons could be manufactured during the other six months, making 3000 tons for the year, the sum of 33⅓ cents must be set aside for depreciation charges for each ton of ice turned out.

If estimate is to be accepted as being more nearly correct for the average small ice factory in actual operation, and experience leads the company to believe that they should, the actual cost per ton for an independently operated ice factory having a capacity of 15 tons would be about as follows:

Two engineers	$ 4.50
Two tankmen	3.00
6700 lbs. coal	10.05
Oil, lights, waste, ammonia and chloride	1.25
Depreciation charges, based on 3000 tons annual output	5.00
	$23.80

This makes a total of $23.80 for the manufacture of 15 tons of ice, or an average of approximately $1.586 per ton.

The question which now suggests itself is: "How does this price compare with the cost of harvesting natural ice?" The local natural-ice dealer claims that it cost $1.10 per ton to put the ice in the house. To this must be added the shrinkage, which is estimated as 50 per cent. for all ice put in storage, so that this cost is really $2.20 per ton.

Electric Heating Without Special Concessions from the Central Station

THE number of electric heating devices in use has increased 100 per cent. during the past year, due as much to the improvement of the apparatus as to the energy of the makers. The proposition of the manufacturers, however, has almost always been accompanied by a suggestion of lower or special rates, which, of course, would help the introduction of the devices; but there are situations, arising from various causes, where a special-rate proposition is not probable, and often not possible. In a paper read at the recent convention of the National Electric Light Association, C. D. Wood, Jr., described some recent applications of heating devices where the devices were made to fit the rates, and not the rates to fit the devices.

The installations investigated are supplied with current generated by steam power; heating propositions that are not possible in the case of a steam station are possible where water is the source of power. In January, 1907, not over 15 per cent. of the central stations in cities of over 50,000 inhabitants in this country and Canada were giving a special rate of six cents or under for heating and cooking.

DOMESTIC DEVICES.

No city in the United States is governed by economic conditions so particularly localized as is the city of New York. The flat-iron, our best ambassador of electric heat, will be used nine times out of ten in homes where the laundry work is in the hands of servants. The best way to install an iron in a city residence under such conditions is to interest the laundress and cook first, and then carry your campaign "higher up." Cards have been distributed to the employment agencies telling about the steps saved by the electric iron, and the same cards have been left at the kitchen entrance; circular letters, with return postal cards, are then mailed to the lady of the house. No matter how ignorant and superstitious your laundress may be, after she has once used an electric iron she will refuse to return to the old one. In one case on record the domestic threatened to leave if the electric iron were not purchased after it had been used on a 10-days' trial.

An average family of five persons, where the collars and cuffs are sent out to be ironed, consumes about 13.2 kilowatt-hours of energy per month, which represents, at a 10-cent lighting rate, an income to the station of $15.84 per year. The automatic handle attachment, which cuts off the current when the iron is not in use, has proved a failure, as the operator invariably ties down the handle. A satisfactory automatic cut-off has yet to be developed.

For summer use, there have been installed in several high-grade dwelling houses electric clothes-dryers, the heating units varying in capacity from 5 to 10 k.w., depending on the size of the dryer. A cabinet eight feet high, eight feet wide and eight deep, may be built in sections, each section equipped with a unit of 2 k.w.; this division makes possible a saving of current when a small amount of work is to be done. During the months of July and August, 1906, a dryer of this capacity consumed about 100 kilowatt-hours per month, which was billed to the customer at a 10-cent rate. The dryer was satisfactory in every respect.

Plate warmers of 800-watt capacity are included in the specifications of the architects in many houses. The New York Edison Company has connected as many as 25 plate warmers in as many different houses in one month. The average consumption of these devices is 24 kilowatt-hours per month.

Of the small home devices, the water cup has been the most pleasing, with the possible exception of the heating pad. The medical fraternity have been approached with electric sterilizers, and found waiting for just such a device. No doctor likes to use gas; his sterilizer consumes about 800 watts, and the average office use of this device is in the neighborhood of 20 kilowatt-hours monthly.

BOOKBINDING.

The bookbinding industry affords an excellent opportunity for electric heat. It is possible to supplant the gas-heated embossing press with electric heating units, and make a very fair comparison with gas, when electricity is sold for five cents per kilowatt-hour. Steam is generally purchased by the month—a 24-hour expense, regardless of when the heat is needed. On the other hand, gas is not clean, nor is the desired heat steady enough for high-grade work.

Of several good installations of this class of apparatus, one has been operating steadily for two years. There are three embossing presses in this equipment. The head of the largest is 19 by 12 inches; the machine has a small panel-board placed within easy reach of the operator, on which are placed two double-throw switches. There are four resistance units in the press-head, placed at equal distances from the center, and by means of a change of connection from series to parallel eight different degrees of heat are obtained. The large press is rated at 220 volts and 16 amperes.

The resistance units may be placed in the holes left vacant by the extraction of the old steam pipes. Some manufacturers supply a hot steel plate, which may be placed next to the die; these plates take about five amperes and are connected to the lighting circuit.

The machine, 19 by 12 inches, referred to above, reached a temperature of 354° F. with an expenditure of 4.07 kilowatt-hours, starting with a room temperature of 75 degrees. The "running" current or low heat was 0.6 kw., which kept the head at the proper temperature while making 480 impressions of the die per hour.

The monthly cost of current for the past year for this work at a 7-cent rate was $8.05 per machine. The Association of Bookbinders is demanding these electric heads.

GLUE-POTS.

Twenty-five inversion coil glue-pots, two-quart capacity, are installed in a bookbinding house on the Edison system. These pots were installed February 1, 1906, and thus far only one has been replaced. The current consumption has been 812.5 kilowatt-hours monthly, or an average of 1.3 kilowatt-hours per pot per working day. Figuring the current at 5 cents per kilowatt-hour, a wholesale price, the cost per month was less than when the company used gas and the work was identically the same. The operators will regard a heat-regulating switch when they will not turn down the gas.

WELDING.

Electric welding has been considered impractical in sections where ordinary power rates of 10 to 6 cents per kilowatt-hour have been available. The New York Edison Company is supplying current for the purpose of welding iron bands used in the trunk industry. By means of a transformer mounted on a frame of the machine the voltage is reduced from 110 to 22 volts. The cross-section of the work is a quarter-inch square. The current consumption of the welding machine under pressure runs from 25 to 35 amperes. The consumption of the machine while making 480 welds per hour is about 1.16 kilowatt-hours, costing 0.02 cent per weld at a 10-cent rate. In this particular case, a motor-generator set was used to generate the alternating current, which materially lessened the efficiency of the whole plant. This work should be particularly interesting to managers of alternating-current systems.

STEEL CUTTING.

Electricity was used in the recent construction of the Hoffman House in New York City, for cutting steel piling. Alternating current at 50 volts pressure was utilized by connecting one cable to the steel piling itself and the other to a carbon electrode that was fastened by a copper plate to a wooden guiding pole. Six hundred and fifty amperes were developed at the arc, which represents 32.5 k.w. of current. In an eight-hour day, 10 feet of piling could be cut, at an expenditure of 260 kilowatt-hours. At 10 cents per kilowatt-hour, the work cost $26 plus the wages of the attendant, which made the total cost exactly $3 per foot of piling. It required two men at $4.50 per day, and two electric drills consuming 44 kilowatt-hours, to drill one foot of piling per day, costing $13.40 per foot. The heating method shows a saving, regardless of time, of $10.40 per foot.

LABORATORY USE.

The milk supply of New York City is governed by tests made in the city laboratory by means of electric stoves. Twenty-five 3.5-inch disc stoves, of 60-watt capacity, are used to boil the ether used in the test. Fourteen times per hour these little stoves cause the ether to vaporize and rise from the containing flask to a condensing chamber that holds the milk to be tested. The ether after condensation is released by a siphon and conducted into the original flask. An open gas flame could not be used for this work.

The medical officer in charge was so well pleased with the operation of these stoves that he wished to heat and regulate his incubator, or germ cabinet, with electricity. The germ producer is 22 by 22 by 22 inches, and the temperatures to be maintained are 100, 110, 120 and 130 degrees centigrade. The cabinet is made of sheet copper with three jacket walls, having a maximum current consumption of 16 amperes. The heavier current is used only 15 minutes of the hour, as three amperes are sufficient to keep up the desired temperature. A thermostat with four contact points furnishes the automatic heat regulation. The regulation has been perfectly satisfactory.

COFFEE AND COCOA DRYERS.

The cocoa and coffee trade has applied electric heat to its small desiccating or drying cabinets. A dryer 3½ feet by 2 feet by 5 feet requiring a temperature of 150 degrees, will need about 74 watts per cubic foot when properly jacketed. One heater of this kind has returned a revenue of $11 per month. The cocoa and coffee beans are particularly susceptible to the odors arising from combustion, hence the advantage of electric heat. For drying kilns about 40 watts per cubic foot are advisable.

CANDY MANUFACTURE.

Warming tables and chocolate dipping pots have proved successful in the candy trade. Fifty watts, or the energy of a 16-candle-power carbon-filament lamp, would produce enough heat to keep the chocolate in working condition. Wherever these chocolate heaters have been installed they are at work to-day. The energy consumed in the device itself is not large, but it will surely lead to more business along this line. The company is figuring with one manufacturing concern to heat a 30-gallon batch of caramel paste to a temperature of 285° F. The operation will consume 10 kilowatt-hours of energy, and each melting will cost about 65 cents. The service is intermittent, hence the adaptability of electric heat. Where high-grade candy is made there is always a chance for electric heat.

SOLDERING IRONS.

The manufacturers of switchboards and telephone supplies find a useful, economical tool in the electric soldering iron; a soldering iron equal to a 1.5-pound soldering copper will consume 70 watts of energy. The operator will accomplish more work with this tool, thereby saving time. Two manufacturers using these devices have stated that soldering irons using current at 5 cents per kilowatt-hour cost less than soldering furnaces operated by dollar gas. This condition is possible because of the actual time saved in doing the work. Heaters of 110-watt capacity are now made, into which a soldering iron may be thrust, thereby doing away with the connecting handle cord. One thousand hogs per hour are stamped "Inspected" by the government meat inspectors in Chicago, by means of a 400-watt branding tool that is nothing more than an electric soldering iron with a die inserted in place of the copper tip.

AN INSTANTANEOUS WATER HEATER.

The statement has been made heretofore that electricity must be sold at 2.5 cents per kilowatt-hour to be on an equal-cost footing with gas at $1 per 1000 cubic feet; also that 2 kilowatt-hours of energy are necessary to raise 20 gallons of water through 40° F. in one hour; these figures are accepted to-day. We are now told of an instantaneous water heater that is ready for the market that will deliver 60 gallons of water per hour at 30° F. above the hydrant temperature (62° F. yearly average) with an expenditure of 4 kilowatt-hours of energy; the water reaches the maximum temperature a few seconds after the switch is closed. The device may be connected to the water service pipe. The water circulates around the heating element (a cartridge unit) without coming in contact with the current, and an automatic device cuts off the current should the water supply fail. A place is predicted for this device in restaurants and cafés.

Electric heat economies are not fully appreciated. A certain manufacturer in New York City has been paying $30 per month for a steam supply that is used in a secret wood-working process. He was persuaded to try electric heat and found that he could do the same amount of work as before with a monthly consumption of 50 kilowatt-hours. He was buying current at 10 cents per kilowatt-hour, and his yearly saving was $300.

THAWING OF WATER PIPES.

For those interested in the thawing of water pipes, a few figures are given showing the details of operation of a 44-cell storage-battery outfit, mounted on an automobile truck, in comparison with those obtained by the use of a rheostat in series with a direct-current 3-wire Edison system with the neutral wire grounded. The figures represent the average amounts in each case.

	Amperes	Kw. Hours	Time, Min.	Pipe, Inch	Voltage	Cost per Case	Revenue per Case
Storage battery	513	1.39	5.44	⅝	31.5	$10.85	$16.40
Edison	275	10.4	19.0	⅝	120.0	14.43	16.93

The Edison system is used until the season has so far advanced that the number of cases will warrant the exclusive service of an automobile truck.

COMMERCIAL COOKING.

Although little has been done in New York City in the introduction of electricity for complete commercial ranges, there are six or eight kitchens in operation, where one meal per day is prepared for the officers and clerks of the various business houses to which the kitchens are attached. The average capacity of these outfits is 10 k.w. A few restaurant broiler sets are used for broiling meats during the noon luncheon hour. These broilers, which are not to be considered complete kitchens, bring a revenue of $12.50 per month, at an average rate of 8 cents per kilowatt-hour. The Waldorf-Astoria Hotel contains the largest cooking unit in the United States. It consists of 19 upright broilers, 4 warming ovens and 4 regular ovens. This device is situated in the south café of the Waldorf, and has a total capacity of 460 amperes.

One manufacturing company in central New York is preparing food daily for 2000 employees, all the food being cooked by electricity.

The greatest difficulty in residential work has been the absence of adequate carrying capacity in risers, special circuits and available extra circuits. The customer will often be willing to pay the first cost of the device; he will accept the consumption figures, but he will flatly refuse to stand the expense of special wiring. Twenty-five possible installations of bathroom radiators were lost in a period of two days' time last winter because of the extra cost of special wiring. To overcome this difficulty and to provide for future business, an agent has been appointed whose business it is to interview architects and contractors for the sole purpose of advising with them regarding the extended use of electricity for heating work; in other words, making it possible for the future owner to use the various heating devices that he desires. Several residences in the City of New York to-day are wired with separate heating and power circuits.

SUGGESTIONS FOR A HEATING AND POWER CIRCUIT IN A FOUR-STORY CITY RESIDENCE HAVING BASEMENT AND SUB-BASEMENT.

The Circuit to be 220 Volts, Connected to a Separate Power Meter.

	Room	Device	Outlet Capacity	Total Ampere Capacity
Sub-basement	Cellar	Ice machine	3.5 amp.	
		Passenger elevator	25 “	
		Ash-lift	3 “	41.5
		Vacuum cleaner	10 “	
Basement	Kitchen	Instantaneous water heater	20 “	
		Kitchenette	30 “	
		Exhaust fan	4 “	
	Butler's room	10-lb. pressing iron	3.5 “	
	Laundry	Clothes dryer	20 “	
		Wash boiler	10 “	
		4-lb. iron	3 “	
		7.5-lb. iron	3 “	93.5
Main floor	Dining-room	Chafing-dish, percolater, and so forth (outlet placed in floor under table)	3 “	
		Portable radiator (outlet placed in wall)	10 “	
	Music-room	Piano player	1 “	
	Parlor	Portable Radiator	10 “	
	Pantry	Plate warmer	5 “	30
		Polishing motor	1 “	
Second floor	Library	Radiator in fireplace	10 “	
	Bedroom	Portable radiator	10 “	
	Front bedroom	Hair dryer, iron, sewing machine, and so forth	10 “	
	Bathroom	Water cup, hair dryer	2 “	
		Portable radiator	10 “	42
Third floor	Bathroom	Radiator, vibrator, and so forth	10 “	
	Front bedroom	Pressing iron, and so forth	3 “	
	Middle bedroom	As above	3 “	
	Rear bedroom	Water cup, heating pad, and so forth	3 “	19
Fourth floor	Play-room	Portable radiator	10 “	
		Electrical toys	2 “	12
		Total		238

If the case in point is a high-grade city dwelling, the following suggestions as to available devices and necessary outlet capacity may be of use:

An installation similar to the above would cost about $850, exclusive of the devices. This figure is based upon a new house and the circuit independent from the lighting circuit. The irons might be placed on the 110-volt lighting circuit, which would reduce the cost of the above installation.

The Nernst Lamp Company during one week received contracts which represent a larger number of candle-power than any individual lighting contract that has ever been made since electric lamps became the popular form of artificial lighting. One of these contracts, from the Baltimore Electric Company, calls for lamps aggregating 1,300,000 candle-power, and another from the Marshall Field Company, of Chicago, for lighting their dry goods store, calls for 700,000 candle-power, making a total of 2,000,000 candle-power. The Marshall Field people only decided upon the Nernst Lamp after they had made an exhaustive test lasting over two years of every other form of modern artificial illumination.

The New York New Haven and Hartford Railroad Runs Regular Trains Electrically

The New York, New Haven & Hartford Railroad Company has begun to run regular electric trains between New York City and New Rochelle, N. Y., and this action will mark the inauguration of a new era in the development of American railways.

The management of the railroad decided some years ago to investigate electric traction with a view of substituting the new power for the steam locomotive. These investigations were carried on in a very exhaustive manner until finally, about a year ago, the railroad decided to install the alternating current single-phase electric railway system, and a contract was made with the Westinghouse Electric & Mfg. Company for the construction of thirty-five locomotives of this type. The same company was also given the order for the power-house equipment consisting of Westinghouse steam turbines, turbo-generators, switchboard appliances, etc., and Westinghouse, Church, Kerr & Company, engineers, were given full charge of installing the entire system.

The work was pushed with the utmost vigor, and the East Pittsburg shops turned out the first locomotive last December. The power-house was completed about the same time and the installation of the machinery began at once, while, in the meantime, the construction of the overhead work had also been started. The last locomotives have been shipped from East Pittsburg. Preliminary runs, tests and trial trips have been made on the new line for months under the supervision of railroad experts and electricians. These were watched with the utmost interest by the entire railroad world, and all proved very successful. The railroad company, being satisfied with the result of these trials, decided to throw the electric road open to the public, and the first train pulled out of the Grand Central depot at New York on the morning of July 21st. Until the first of August trains were run only as far as New Rochelle; beginning August 1st the schedule was extended to Portchester, and by September 1st the company expects to be running electric trains between New York and Stamford, Conn. The service begins with thirty-five 1000-horse-power locomotives, each capable of pulling a train of ten coaches at an average speed of 75 miles an hour.

The inauguration of the single-phase system on one of America's foremost main line railroads marks an epoch in the development of the railroad business in this country.

Westinghouse Electric and Manufacturing Company, Engineering Executives

While commenting upon the excellent annual report of the Westinghouse Electric & Mfg. Company, a well-known financier remarked:

"One of the most important factors that has brought about the phenomenal business records of the company within the last year is the perfect organization which dominates all departments. It must be extremely gratifying to Mr. Westinghouse, whose business sagacity and foresight brought this about, and it cannot help being pleasing to the stockholders to know that their property is under such an efficient management."

E. M. Herr, the chief executive under Mr. Westinghouse, has had exceptional experience as an engineer and manufacturer. He was for a time the successful head of the locomotive department of the Northern Pacific Railroad, where he showed great tact in the management of men and won a national reputation for his expert skill in the construction and operation of locomotives. In 1898 he became vicepresident and general manager of the Westinghouse Air Brake Company, and it was his remarkable record in that position which undoubtedly prompted Mr. Westinghouse to place Mr. Herr in charge of the Electric Company at a time when his qualities were quite essential to its success. Mr. Herr became vice-president of the Electric Company in 1905, and his connection has proved most effective in improving the affairs of the company.

L. A. Osborne, the second vice-president of the company, in charge of the engineering and commercial departments, is a remarkable young man who, though he is but 35 years old, has demonstrated during his career with the company an engineering skill as well as a capacity for management which place him among the leading men of the industrial development of this country. He is familiar with every detail of the company's engineering and commercial work, and since Mr. Westinghouse, a year ago, placed him in the important position which he now occupies, he has proved a great success.

In the engineering department, the leading men are B. H. Lamme, C. F. Scott, H. P. Davis, N. W. Storer and others, all known to the electrical profession the world over for their valuable contributions to the great achievements in the electrical industry during the last twenty years. To them belongs the credit for the development of the single-phase alternating current railway motor and the many details essential to its operation, an achievement which makes the Westinghouse Company the most important factor in the modern electrification of railroads.

To these men also belongs the credit for the product of the Westinghouse Company having gained a world-wide reputation for superior electrical excellence and perfect mechanical construction.

The July business of the Westinghouse Electric Company was considerably above the average. The last information from East Pittsburg stated that the railway department alone showed a record for orders booked approximating about $2,500,000. Among these were two of more than ordinary importance. The Brooklyn Rapid Transit Company contracted for 400 electric railway motors, 200 of which, of 200 horse-power each, are for the elevated railroad cars, while the balance, of 60 horse-power each, will be surface car equipment. In connection with the elevated car equipment, the company will also furnish the Westinghouse Multiple Unit Control. The other large order comes from the Schoepf interests of Cincinnati, which control one of the largest urban and interurban electric railway systems in this country, operating cars in eastern and central Ohio and southern Indiana. This order includes a complete equipment of electrical apparatus for 24 sub-stations, consisting of rotary transformers and switchboard appliances, as well as four Westinghouse turbo-generators aggregating 26,000 horse-power.

The Westinghouse Electric and Manufacturing Company are now turning out sixteen locomotives for coal mines in West Virginia and Kentucky, one for an iron mine in Sweden, another for a power company in the State of Washington, and one for a plate glass mill at Charleroi, Pa. They are constructing a complete electric motor equipment for a phosphate mine in Florida, for a lumber camp at Mount Pleasant, Pa.; they have in hand an order for 39 motors to drive machinery in a cash register manufacturing plant at Dayton, O.; they are turning out 59 motors for driving textile looms at East Hampton, Mass., and a larger number for running spindles in a worsted mill at Passaic, N. J. Fifteen motors are going to a paper mill in Canton, N. C., and twenty to a paper mill in Fulton, N. Y.

Most of the Westinghouse companies are now making considerable additions to their works in order to increase their manufacturing facilities so as to meet the constantly increasing demands for their products.

The new eight-story steel structure which is being erected by the Electric Company is pushed with the utmost vigor and the contractors have given an assured guarantee that the building will be ready for occupancy by August 1st. This will give an addition of 250,000 square feet of floor space, to be utilized for the construction of details and supplies. This should greatly relieve the congested conditions which now exist in most of the departments at the East Pittsburg works, where every square foot of available space is now occupied.

Judging by the improvements and enlargements now under way at the works of the Westinghouse Air Brake Company in Wilmerding, the railroads are making, at present, greater demands for brake and draft gear equipment than ever. The Air Brake Company has now about 4000 employes at work, a larger number than it ever had on the pay-roll heretofore. The shops, however, which it was thought at one time were large enough to supply the entire brake requirements of the railroads of this country for a long period, have already proved inadequate. The company has now in course of erection a core shop 85 x 140 feet, a pattern shop and pattern storeroom 80 x 330 feet, and is about to begin the erection of a new carpenter shop 45 x 120 feet. The works of the Air Brake Company have never been busier than at present, the output has never been larger and the outlook for future business has never been brighter.

The Union Switch & Signal Company has several hundred men at work on the site recently acquired for the erection of additional shops, which the company requires for the enormous growth of the business experienced within the last year or two. At the present moment every department at the Switch & Signal factory is working to its fullest capacity and with the amount of orders already on hand the management is looking forward to the completion of the new works, so as to relieve the crowded condition of the old shops.

All of the Westinghouse companies declared the usual quarterly dividend, the Air Brake Company 2½ per cent. regular and 2½ per cent. extra, the Switch & Signal Company 3 per cent. on the preferred and 3 per cent. on the common stock, the Machine Company 2½ per cent., and the Electric Company 2½ per cent.

The Products of a Great Industrial Company as seen in its Exhibit at the Jamestown Exposition.

SO much stress has been laid on the naval and military features of the Jamestown Exposition that the importance of the display made by commercial and industrial interests is not unlikely to be overlooked by the public of the country at large. Every State in the Union is, however, represented industrially, and many foreign governments were among the first exhibitors to secure space for a similar purpose. This feature of the great fair is developing beyond expectation, having exceeded the plans originally made for the exploitation of manufactured articles of trade, and it is proving one of the leading attractions.

Among the principal exhibits of machinery to which visitors will be early attracted is that made by Allis-Chalmers Company, of Milwaukee, occupying Section 8, Machinery and Transportation Building, as shown in part by the accompanying illustration.

The character of this exhibit is not marked by the display of any unusual or special apparatus, nor does it include specimens of all Allis-Chalmers Company's extremely large and varied line of products, but only a few of the standard machines whose designs have been well established, such as are used in thousands of installations the country over, and are doing efficient, economical, every-day service.

The larger machines seen at the back of the picture, a No. 5 style "K" Gates Breaker and an Allis-Chalmers Band Mill, with Saw Mill Carriage, are representatives of three important branches of industry in which Allis-Chalmers Company is the acknowledged leader; namely, the manufacture of complete rock and ore crushing equipments, cement making plants and saw-mill machinery.

The breaker is identical with those used by the Pennsylvania Railroad in the concrete construction of its famous tunnel under the East River, New York, a model of which is exhibited just across the aisle; and the band mill might be taken for a twin of one which recently broke the timber-sawing record of the South.

The electrical machinery shown includes a belted alternator and an Allis-Chalmers Reliance Engine, the latter of which is hidden in the background of the picture. This company, as builder of both Corliss engines and electric generators especially designed for operating with them, offers a proposition of a decided advantage to the purchaser, who is able to deal with a single concern and thereby avoid any division of responsibility for the satisfactory operation of both the steam and electrical ends of his power-plant.

There is also shown a complete line of apparatus for electric drive, including standard Allis-Chalmers induction motors and direct current motors, whose liberal design and uniformly excellent service have distinguished them above the machines of all competitors.

In the photographs, model and parts of Allis-Chalmers steam turbines shown in this exhibit may be observed three of the special features which have given these units the commanding position that they now occupy, viz.: channel-shaped shrouds protecting the ends of the blading from injury, machine cut slots in the foundation rings insuring absolutely accurate spacing of the blades, and improved arrangement of balance pistons reducing the diameter of the cylinder and preventing distortion under varying temperatures. These features are patented, and controlled by Allis-Chalmers Company, in the United States, Canada and Mexico.

The greatly extended use of compressed air for driving drills, pneumatic riveters, hammers, cleaners, clipping and calking tools, etc., has created a strong demand for small air compressor plants which may be placed conveniently to the work in hand. A portable compressor outfit mounted on a truck, comprising a Christensen Air Compressor, built solely by Allis-Chalmers Company, driven by an Allis-Chalmers motor, may be seen here with all its accessories.

At either corner of the space are placed large swinging racks of frames containing photographs and illustrated summaries of bulletins of the principal products of Allis-Chalmers Company, viz.: steam engines, gas engines, steam turbines, hydraulic turbines, condensers, electric generators, motors, transformers, traction equipments, pumping plants, cement mills, rock crushing plants, dredges, steam shovels, flour mills, saw mills, air brakes, hoists, mining, milling and refining machinery and timber preserving plants.

Attendants at the exhibit make it a point to answer all inquiries and those who are interested in obtaining copies of Allis-Chalmers bulletins may do so by leaving their names and addresses, to which the printed matter will be mailed.

ALLIS-CHALMERS EXHIBIT AT JAMESTOWN EXPOSITION.

Allis-Chalmers Induction Motors Belted to Paint-Grinding Machinery versus Motors Direct Connected

THE paint-grinding machinery of a certain large Western manufacturer of pigments, the Wadsworth-Howland Company, of Chicago, has for some months past been operated by means of forty-odd Allis-Chalmers three-phase, 60-cycle, 220-volt, belted induction motors, ranging from 1 horse-power to 30 horse-power, all of which are suspended from the ceiling.

The motors are at present operated by power purchased from the local lighting company, although a 100 k. w. engine driven alternator is available for use if necessary. In order to ascertain the exact difference in power consumption between belted and geared motors, and the relative efficiencies of the two methods, a test was made on one of the paint grinders, and the power actually consumed was accurately measured, using first a belted Allis-Chalmers motor, and second a geared motor of another design.

The mill on which the tests were made is used for grinding yellow ochre, after it has passed through a mixer. The machine consists of two pairs of mill-stones about 30 inches in diameter, each mounted with axis vertical. The lower stones of each pair revolve while the upper stones are fixed. One pair of stones is located in front of and below the other, so that the paint discharged from the upper pair will drop into the hopper of the lower. The fixed stones are fastened to the frame of the mill, while the lower revolving stones are carried on the ends of vertical shafts connected together by spur gearing and driven from the main shaft by a bevel gear and pinion. The main shaft runs at a speed of approximately 132-136 R. P. M., and with the present belted outfit is provided with tight and loose belt pulleys. The mill is driven from a small countershaft located directly above the main shaft, the motor being suspended from the ceiling and located about 10 feet from the countershaft.

Paint mixed with linseed oil is fed, from a mixer, into the upper pair of stones, and after passing through them is discharged into the lower pair. The process is continuous, and when the mill is first started it requires considerably more power than after an hour or so, when the stones have become heated and the paint more easy flowing. The power required also depends on the rate of feed, and the setting of the stones; if the stones are too tightly adjusted the power required is very much increased. In these tests every precaution was taken to have the adjustment of the stones, and the rate of feed the same in each case; the wheels for adjusting the stones were marked so that they could be brought to exactly the same position in each test.

TEST ON BELTED MOTOR.

Each of these grinders is provided with an individual 10 horse-power belted motor running at approximately 1130 R. P. M at full load, and equipped with a type "A" potential starter. The following tests were made: First, motor running idle with belt off; second, motor running belting and countershaft, mill belt on loose pulley; third, motor running mill and grinding paint.

In tests one and two, readings of volts, amperes and watts were taken, Weston instruments being used for measuring volts and watts. Current was measured by a Thompson ammeter, which had a range of only 15 amperes, and hence was not available for load readings. In test three, indicating wattmeter readings were taken at the beginning and end of the test, and in addition a Fort Wayne polyphase recording watt-hour meter, installed by the lighting company, was placed in circuit to record the total watt-hours during the run. A four-hour run was made, the mill being cold when started. Allis-Chalmers motor 10 horse-power, 220 volt, 26 amperes, 3 phase, 60 cycle, 1130 R. P. M.

SUMMARY.

	Belted	Geared
Watts, (Motor Running Idle)........	600	400
Watts, (Motor Running Belt and Countershaft)......................	900	....
Watts, Motor Running Mill (Beginning to run)......................	10300	12300
Watts, Motor Running Mill (End of run)............................	7200	8500
Kilowatt Hours for 4 Hours Run (from recording Wattmeter)...........	26	28.5
Total Weight of Paint Ground, Pounds	86.75	73.5
Average Power Factor..............	90	80

From the wattmeter readings given, and also from the recorded power consumption for the four-hour run, it is plain that the geared slow speed motor, instead of saving power, actually requires about 10 per cent. more power than the belt drive. On a longer run the showing of the geared motor might be improved somewhat, because the overload period, during which this motor has a low efficiency, would then be a smaller part of the total. It will be noted that the amount of paint ground with the geared motor was less than with the belted, showing that the greater power consumption was not due to any increase in the amount of paint fed into the mill.

The geared motor must necessarily be run at slower speed than the belted, and a slow speed 60 cycle motor of small output is inferior in electrical performance to a higher speed belted machine. Its no load losses may be less than for the belted motor as in the present test, but its efficiency at or near full load will be lower.

The lower power factor of the slow speed motor is not a great objection where power is supplied from a large system, since power is measured by watt-hour meters. If, however, the motors were at any time operated from the customer's isolated plant, the lower power factor would be a decided disadvantage, as the current output of the generator is limited.

The amount of paint ground in each case was considerably lower than would have been obtained under average conditions, because the mill-stones were not in first-class condition. This, however, does not affect the value of the tests as concerns relative power consumption, because the condition of the mill was the same in each case. Also the recording wattmeter readings were low compared with those of the indicating instrument, which was carefully checked before the test and found to be accurate within 1 per cent. The same instruments were, however, used in each test, the primary object of which was to obtain comparative data.

Allis-Chalmers Hydraulic Turbine and Generator at Nelson, B. C., Betters Guaranteed Performance

A TEST run of an Allis-Chalmers Hydraulic Turbine Generator unit was recently conducted at the city power plant of Nelson, B. C., in the presence of city officials, which resulted decidedly in favor of the apparatus. The turbine generator unit has a normal capacity of 750 k. w., but during the test run this output was increased to 1340 k. w. for a period of over 45 minutes continuous running without undue increase in temperature of bearings.

The usual tests were made as to the heating of the coils and bearings. According to the guarantees the armature and field coils did not rise in temperature above 35 degrees centigrade.

The supply for light and power has been furnished up to the present time by the West Kootenay Power & Light Company, situated just across the Kootenay River from the new city power plant, out of which source both companies derive their power.

The hydraulic turbine, which is of standard design, was built at the Scranton, Pa., works of the Allis-Chalmers Company, and the generator, which is the vertical type, specially designed for direct connection to hydraulic turbines, was built at the electrical works of the Allis-Chalmers Company, Cincinnati, Ohio.

Milwaukee Northern Railway to be Placed in Operation by Early Fall

THE line of the Milwaukee Northern Railway between Milwaukee and Port Washington will probably be ready for operation early in September and all work is being pushed as rapidly as possible to that end. From a point a little over two miles north of Milwaukee to the town of Grafton, a short distance from Port Washington, tracks are laid. All grading between these points has been practically completed. The force of men engaged in this work will shortly be put on the work between Port Washington and Sheboygan, where another gang of workmen has been clearing the right of way. The Allis-Chalmers gas engines are being erected in the main power-house at Port Washington.

The complete power equipment was built by Allis-Chalmers Company, Milwaukee. Three phase alternating current will be generated in the power-house at 405 volts by three direct-connected Allis-Chalmers alternators, each of 1000 k.w. normal capacity, driven at 107 R. P. M. by Allis-Chalmers twin tandem gas engines, each with a rated capacity of 1500 horse-power. This equipment, when in operation, will constitute the largest installation in America of gas engine-driven electric generating units used for traction purposes.

Allis-Chalmers Lighting Equipment for Little Valley, N. Y.

THE town of Little Valley, N. Y., has recently closed the contract for a new electric lighting equipment which will compare favorably with that of any town of its size in Western New York.

There are included in the contract an Allis-Chalmers 150 k.w., 60 cycle, 1100 volt alternator, an 8 k.w. 120-volt, direct-connected exciter and an 18" x 42" Allis-Chalmers Corliss engine of 250 horse-power heavy duty type.

The new engine runs at a comparatively low speed of 80 R. P. M., as against the 265 R. P. M. of the units which were formerly in use. The fly-wheel alone for this unit weighs 14,000 lbs., and the new equipment will readily carry a load of 4000 incandescent lamps and 25 arcs.

The feature of the Little Valley plant, which will be marked by the introduction of the new units, lies in the fact that, owing to the old equipment being retained, a complete duplicate system will be available for service under all conditions.

The Royal Multiplex Lamp and Attachment

This lamp has been designed to take the place of acetylene burners in search lights, head lights, regular gas lamps, standard oil lamps and tail lamps. The Multiplex lamp derives its name from the fact that several filaments burned simultaneously in one bulb. This lamp is manufactured for 4, 6, 8, 10 and 12 volts regularly. The 6-volt lamp uses 1½ amperes and gives 16 candle-power; with mirror reflector the candle-power is twice this amount. The 8-volt lamp gives the same candle-power, but uses only 1¼ amperes. The filaments are made from a rare metal which greatly reduces current consumption and gives a more brilliant light than could be obtained with the old carbon filaments. Should one of the filaments break the lamp would still give a large amount of light; even if three filaments should break or burn out the lamp would still give light. Oil attachments and gas attachments are made which allow of adopting the Multiplex lamp to oil and gas lamps. Each outfit is supplied with ten feet of rubber insulated silk covered cable. The two set outfit has one attachment with ten feet of cable,

ROYAL MULTIPLEX LAMP.

the other attachment having five feet of cable to make connections with the first cable. The two attachments are controlled by one switch.

The Electric Cable Co.

The Electric Cable Co., of New York, has just bought the entire business of the Eastern Wire and Cable Co., of Roxbury, Mass. The latter company is one of the oldest and largest manufacturers of rubber-covered wires and bales in New England. Its entire equipment will be removed to Bridgeport, Conn., where it will be installed in the plant of the Electric Cable Co., which has in course of construction a large addition to its plant.

The officers of the Electric Cable Company are: President, Edwin W. Moore; Vice-President, F. H. Cowles; Treasurer, J. Nelson Shreve.

Northern Engineering Works

The Northern Engineering Works, crane builders, Detroit, Mich., have installed power station cranes, one of 20 tons capacity for the Toledo Gas and Electric Co.; and two of 20 tons capacity in the Murphy Power Plant at Detroit, Mich.

The Atlantic Coast Line Ry. Co. have installed at South Rocky Mount plant a 5-ton, 3-motor Electric Northern traveling crane, span about 72 feet. This crane was furnished by the Northern Engineering Works, Detroit, Mich.

Speer Carbon Co., St. Mary's, Pa., have been experimenting for the past year on a new reinforced carbon brush which they are now putting on the market. This brush is meeting with phenomenal success. If any consumer is having brush trouble, samples of same can be had by writing the above company.

Electrical Work in Turkey

TURKEY is practically a virgin soil for electrical enterprise, writes United States Consul E. L. Harris from Smyrna. Up to a year ago there was not a single city or town in the 800,000 square miles of Turkish possessions which could boast of a telephone system or of a central station for electric light or power purposes. Now Damascus and Beirut have their electric central stations. however queer it may seem that the former ancient city should lead in progress the important and quasi European cities of Constantinople, Smyrna and Salonica.

Quite recently concessions were granted for electric light and traction in Constantinople, Salonica and Brussa. Smyrna, the second city in the empire, and perhaps the first in commerce and future prospects, seems to have no immediate future for electrical appliances, although perhaps no city feels more the need of them. It is rumored, however, that permission has been granted for the electrification of the two-mile tramway line between Smyrna and the suburbs on the southern shore of the gulf.

Aside from a few isolated plants in mines and private residences, the concessions referred to represent the sum of electrical work in Turkey. Belgium has so far taken the lead in securing large contracts, while Germany, with the exception of the Constantinople concession, nearly monopolizes the smaller business, the material for which has to be imported by special permission from Constantinople. The prohibition now covers everything relating to electricity, even the serviceable electric bells, which cannot be imported except with the approval of the direction of customs in Constantinople.

It is persistently rumored that this unaccountable prohibition of electrical apparatus will be raised within the near future. It would be wise for American manufacturers of electrical appliances to turn their attention to this unexplored field and use their characteristic energy in securing a fair share of the coming trade.

New Motor Rheostats

THE National Board of Fire Underwriters recently proposed a rule bearing on the vital part of a motor-starter, the resistance, which has aroused general interest. This rule stated that the resistance conductor should possess a low or negligible temperature coefficient. One of the arguments against the proposed rule was to the effect that resistance material of low temperature coefficient cost so much that motor-starting rheostats would have to be built with less material. This, it was stated, would require that the resistance material be imbedded close to a heat absorbing mass and such constructions would interfere with the rapid cooling of the rheostat.

In the light of this discussion the new motor-starting rheostats just placed on the market by the General Electric Company have special interest. (Fig. 1.) This line of rheostats with no-voltage release, known as Type SA, and with no voltage and overload release, Type SQ, is constructed with a new resistance unit not only having a negligible temperature coefficient but also permitting a ventilated construction of the rheostat.

The new resistance, designated the Form P unit, consists of a low temperature resistance material wound on a tube which is ventilated inside and out. The whole is covered on both surfaces with a special compound, which effectively protects the wire and holds it in position. The unit so formed is absolutely fire and moisture proof, and, if accidentally raised to such a degree of heat as to melt the wire, will open the circuit without appreciable arcing. The design of the Form P unit, furthermore, increases the starting capacity of the rheostat from a duty of 30 seconds to a duty of one minute without increasing the dimensions.

In addition to these excellent electrical characteristics, the new unit permits many improvements in detailed mechanical construction. Because of the reduced space which the Form P unit occupies, not only is the space required per horse-power much less, but more room is available in which to make internal connections. This, together with the fact that all leads are insulated with glass beads, eliminates danger from grounds or short circuits caused by crowded leads. The glass beads are excellent insulators and are also absolutely fireproof.

The Form P resistance unit as described is used in rheostats of the following sizes: From 1/8 horse-power up to and including 15 horse-power at 110 volts; from 1/8 horse-power up to and including 30 horse-power at 220 volts; and from 1/8 horse-power up to and including 35 horse-power at 550 volts. In rheostats of 2 horse-power and larger, the Form P resistance units are fastened to supports independent of the iron cover, these supports being fastened to the slate top of the rheostats. (See Fig. 2.) This allows the resistance unit to be removed for inspection or repairs without disturbing other units or connections. In larger rheostats the iron grid type of resistance is used, the grids being treated with a compound which prevents rusting.

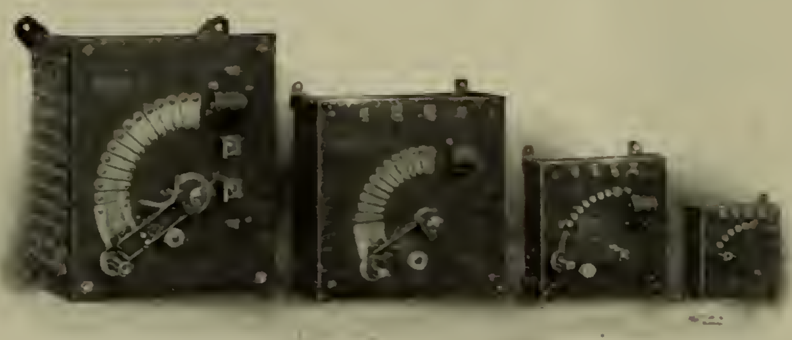


FIG. 1.—MOTOR-STARTING RHEOSTATS.

The mechanical features of the new rheostats have also received thorough consideration. Necessarily subjected to hard service, the switch arms, contact shoes, segments and connections are all designed to meet such conditions.

The arms of the dial switches are of rugged construction and will undergo heavy handling without injuring the contact between the sliding brushes and the segments. The springs which pull the arms to the "off" position encircle the pivot stud and are positive in action. The arms may be easily removed from the rheostat by slipping out a cotter-pin. The dead segments on the starters have been made of ample proportions to insure the proper breaking of the current when the switch arm flies to the "off" position.

In the smaller sizes the sliding contacts consist of copper shoes held down firmly on the segments by springs. On motor rheostats above 7½ horse-power, 110 volts; 10 horse-power, 220 volts; and 15 horse-power, 550 volts, brass blocks are provided with carbon protecting blocks which precede the brass blocks while starting; this prevents pitting. The contact blocks, in all sizes, are self-aligning and can be renewed readily without removing the switch arm from the slate.

Care has also been taken with the stationary contact segments. The stationary contacts on smaller sizes are of brass, while on rheostats of larger sizes all the stationary contacts are made of copper and are renewable from the front. Rheostats in the larger sizes also have the initial contact point protected by an auxiliary button which may be removed and renewed from the front.

The motor shunt field circuit is made and broken on the first live segment of the starting switch. When the starting arm passes to the "off" position the field is discharged through the motor armature and the starting resistance. This resistance, however, is not in series with the field in the "running" position.

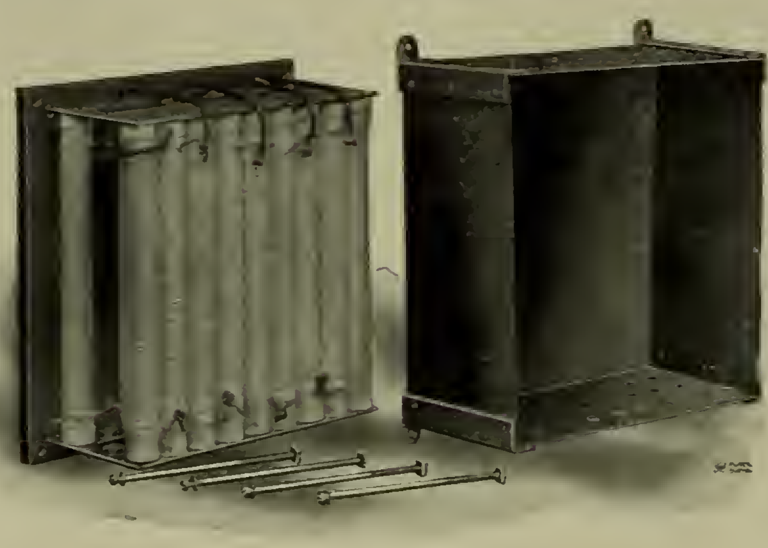


FIG. 2.—RESISTANCES.

All of the rheostats are fire and moisture proof and are built to withstand the hardest service. They are suitable for starting direct current motors. The general appearance of the rheostats is shown in the accompanying illustrations.

BOOK REVIEW

Armature Construction

MESSRS. HOBART & ELLIS have gotten out an attractive book, entitled "Armature Construction," which is devoted to the design, construction and testing of alternating and direct current armatures. Very complete winding diagrams are shown which are made exceedingly clear and readily followed by the adoption of colored inks for the different circuits. The chapters are devoted to armature laminations and their preparation, the armature frame, armature core ventilating pieces, assembling the armature core, construction of squirrel cage armatures, commutator construction, continuous current armature winding system, alternating current armature winding system, insulating of armature conductors, the winding of continuous current armatures and the design and construction of winding forms, the winding of alternating current armatures, finishing and testing; besides an introductory chapter devoted to a discussion of the different types of generators and motors. Examples of construction are largely taken from European practice, though American machines are not entirely neglected. Dimensions are expressed in c. g. s. units. The book is non-mathematical, being more confined to methods of construction than to the design of armatures. It is well written, and will be of value to those engaged in the manufacture and construction of electric generators and motors. The Macmillan Company are the New York publishers.

The Art of Cutting Metals

"THE ART OF CUTTING METALS," by Frederick W. Taylor, M.E., Sc.D., which was the presidential address presented at the last annual meeting of The American Society of Mechanical Engineers, has been reprinted and bound in cloth by the Society, price $3. This or any other publication of the Society may be had by addressing the secretary, 29 West 39th Street, New York. It is not necessary to send orders through members. None of the publications of The American Society of Mechanical Engineers are copyrighted.

Handling Baggage Electrically

An improved method of handling passengers' baggage at large stations is being tried by the Pennsylvania Railroad in Philadelphia. Baggage and mail trucks that are practically miniature automobiles have been adopted. A storage battery and electric motor are mounted beneath the platform. The attendant has merely to steer, the whole work of propulsion being performed by the motor. If the use of these trucks continues as successful as reported, they will, it is said, replace the old hand-propelled trucks at the larger stations on the system.

CATALOGUE REVIEW

The Westinghouse Electric Manufacturing Company are preparing for publication an instruction book for Type R motors and generators, giving in detail all data as to location, foundations and erections of these machines with other information regarding idler pulleys. The methods of operation and maintenance, with instructions for care of brushes, bearings, armatures and commutators are given under their respective headings; causes of and remedies for sparking are tabulated, and chapters are devoted to excitation, grounds and hot bearings. Another section of the book tells how to make repairs on field coils and armatures with method of removing shaft and reassembling the machine. Wiring diagrams for starting rheostats with internal rheostat connections are shown, a number of pages contain blanks for filling out the armature winding connections and there is a complete list of wiring diagrams for bi-polar and multi-polar machines.

They also have in course of preparation a circular entitled, "Integrating Wattmeters for Single Phase and Polyphase Alternating Current Circuits and for Direct Current Circuits," which gives all details of construction of these meters for house and switchboard service, both two wire and three wire, including the portable standard testing meter. There are also numerous diagrams showing the connections to different circuits, with and without transformers.

Westinghouse Incandescent Lamps are fully described in publication 4,003 distributed by the Westinghouse Lamp Company. The classification is as follows: Standard lamps, mill type lamps, round bulb lamps, tubular lamps, reflector lamps, railway lamps, street series lamps, miniature lamps, frosted lamps and colored lamps. A table gives the life of lamps when burning at efficiencies of 3.1, 3.5 and 4 watts per candle-power. They supply the Edison base regularly with the option of other bases on order. The standard candle-power measured by comparison with the British Parliamentary standard candle-power as furnished by the National Bureau of Standards at Washington is the unit on which ratings are based. All types of lamps are illustrated to scale, the length and diameter are given in inches, and the voltage, candle-power and watts per candle-power are specified for each type. Adapters for converting T. H. and Westinghouse sockets for the Edison base lamp are also illustrated and described.

"Electric Lighting in the Department Store," "The Glower," and "A Departure in Office Buildings" are the titles of interesting and instructive booklets issued by the Nernst Lamp Company. These booklets give new ideas as to the distribution of electric lamps with special reference to the Nernst type of lamp.

The Westinghouse Machine Company send a copy of their catalogue describing storage batteries for stationary service. A complete description of the line of batteries is given, as well as information regarding their battery regulator and battery booster.

Standard gears, including brass, iron, steel, rawhide and fibre gears; also gears for special purposes—spur gears, pinions, mitre gears, bevel gears, internal gears, etc., are completely described and catalogued in Catalogue E issued by the Boston Gear Works.

Bulletin No. 46, dated August, 1907, has been received from the H. T. Paiste Company. Their new entrance switch boxes and panel boxes are shown, also a line of receptacles, rosettes and plug cut-outs.

The Bryant Electric Company catalogue electrical supplies in a neat pocket form. They list a number of brass, aluminum and porcelain sockets for 250 and 600 volts in a number of different styles—electrolier, twin, with chain switch, for street hoods, wall sockets (both straight and angle), rosette sockets, porcelain receptacles, weather-proof sockets of porcelain and moulded insulation, miniature and candelabra receptacles; also their complete line of switches, cut outs and fuses.

Every engineer engaged in the design of electric railways should obtain a copy of the "Electrification of the West Jersey & Seashore Railroad," recently distributed by the General Electric Company. A map of the electrified lines is shown, followed by a description of the roadway, rails and transmission lines. The power station and sub-stations are also completely described with line cuts reproduced from working drawings. Minute details of third-rail construction and of the transmission line are described and illustrated and complete information regarding the car construction, trucks and brakes is given in tabular form.

The General Electric Company also send the July number of the "General

Electric Review." The paper is well written and ably describes the General Electric apparatus.

Catalogue No. 17, issued by William H. Bristol contains a complete description of electric pryometers for indicating, recording and controlling high temperature. Several records are shown as recorded by the pyrometer in actual service. The indicating pyrometers are made for switchboard service, and also with a wooden case for portable use. The recording pyrometers make continuous records of all ranges of temperature to 3000 degrees Fahrenheit. Several applications are given with diagram drawings.

The Emerson Electric Manufacturing Company publish an attractive monthly, the August number of which has been received. Naturally the largest part of the monthly is devoted to electric fans and small power motors. The information given will be found of value to those engaged in the application of small motors to the electric operation of machinery.

One of the most complete and modern lines of brass and iron specialties is shown in the catalogue of The Wm. Powell Co., of Cincinnati, which has been mailed to their customers.

This catalogue presents their line in a most complete and practical manner, giving dimensions of every article for which a dimension may be required, and explaining in detail the merits of their well known specialties.

A valuable series of tables and rules is bound in with the catalogue, giving in a concise form information that every engineer and shop manager requires in his daily practice. A copy is yours for the asking.

An interesting book on motors was recently issued by the Robbins & Myers Co., of Springfield, O. The various types are illustrated and fully described, and in the two pages devoted to notes on the selection of motors is contained not a little valuable information to prospective purchasers. A number of views show the application to various kinds of work.

A bulletin recently issued by the General Electric Co., of Schenectady, N. Y., is devoted to the timely subject of electric flat-irons. A number of illustrations are shown of the various types and of laundries and other places where the irons are in use. Other bulletins sent out deal with commutating-pole railway motors, electrically operated, ratchet-driver rheostat switches, knife blade lever switches, lightning arresters, and single-phase, high-torque induction wattmeters.

The General Electric Company has just issued a flier entitled "More and Cheaper Light," drawing attention to its tantalum incandescent lamp which admits of a saving of approximately 35 per cent. over the most efficient carbon filament lamp. The lamp is made in only one size—22 candles consuming 44 watts—and is approximately 12 per cent. cheaper to burn than the 50-watt incandescent lamps, besides being 35 per cent. stronger in candle-power. Lamps combined with the Holophane pagoda reflector, give about 58 candle-power downward. Stanley & Patterson, Inc., of New York, carry this lamp in stock.

A very complete pamphlet on electrical measuring instruments was recently sent out by the Leed & Northrup Co., of Philadelphia. The list includes condensers, galvanometers, shunts, slide-wire and other bridges, resistance standard apparatus for measuring low resistances, resistance boxes, Wheatstone bridges, ohmmeters, portable testing sets, potentiometer, electro-dynamometers, a. c.—d. c. comparators, self- and mutual-induction apparatus, precision photometers, resistance thermometers and temperature indicators.

A series of bulletins recently sent out by the Fort Wayne Electric Works is devoted to small power motors, single-phase motors, Type EF direct-current motors and direct-current series enclosed arc lamps.

"A Study in Graphite" is the title of a booklet recently issued by the Joseph Dixon Crucible Company, of Jersey City, N. J. It gives in detail a series of tests of graphite made by Professor W. F. M. Goss, of Purdue University. Complete descriptions of the tests are given, together with illustrations of the testing machine. The condition of the bearings and journal is shown by photographs taken at different stages of the tests. Because of the high character of the matter and the heavy expense attached to the conduct and publication of these tests, it was decided to make a nominal charge of twenty-five cents a copy for "A Study in Graphite." A limited number of copies, however, will be distributed free of charge to all those interested in the science of graphite lubrication.

A bulletin recently sent out by the United States Bureau of the Census is devoted to the manufacture of electrical machinery, apparatus and supplies during 1905. In that year the plants engaged in these lines numbered 784, with a capital of $174,066,026, the average number of wage-earners employed being 60,466, and their wages, $31,841,521; the cost of materials used, $66,836,926, and the value of products, $140,809,369.

The percentages of gain since 1900 are: Establishments, 34.9 per cent.; capital, 108.1 per cent.; number of wage-earners, 43.9 per cent.; amount of wages paid, 54.7 per cent.; cost of materials, 35.1 per cent.; value of products, 52.3 per cent. In addition to the products reported by these plants electrical machinery and supplies, valued at $18,742,033, were produced by 128 establishments engaged primarily in other lines of manufacture.

Throughout the States the distribution of electrical manufacturing has remained the same in all essential respects. New York, Illinois, Ohio, Pennsylvania, Massachusetts, Connecticut, Indiana and New Jersey reported 631 of the 784 establishments making electrical apparatus at the census of 1905, and products valued at $126,807,804, or 90.1 per cent. of the total for the country.

The total value of dynamos and motors, which constitute the largest single class of electrical apparatus manufactured in the census year, was $33,454,860. A slight increase in the value of all dynamos (from $10,472,576 in 1900 to $11,084,234 in 1905) was associated with a very large increase in number (from 10,527 to 15,080) and in capacity (from 770,832 horse-power to 1,328,243 horse-power). It is obvious that a relatively small increase in the average size of machines was accompanied by a large decrease in the cost per horse-power to the purchaser.

Of the total number of dynamos, 13,756, having a capacity of 853,800 horse-power and a value of $6,973,130, were direct-current, and 1,324, with a capacity of 474,443 horse-power and a value of $4,111,104, were alternating current. The number, horse-power and value of the direct-current dynamos were greater in 1905 than in 1900, whereas the alternating-current dynamos increased in capacity only.

In 1905, 66,698 transformers were manufactured, having a capacity of 970,908 horse-power and a value of $4,468,567. The value of switchboards intended for electric light and power and electric railway work has advanced from $1,846,624 in 1900 to $3,766,044 in 1905.

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Electric Illumination

THE subject of electric illumination was formerly divided into two general classes—one, the incandescent lamp, and the other the arc lamp. With the introduction of the Nernst lamp, incandescent lamps of high power, tantalum lamp, and similar forms of improved methods of lighting the gap between small units of 16 candle-power and 8 candle-power, and the larger units running from 800 to 2000 candle-power has been completely bridged, so that now a form of electric lamp can be chosen to suit any conditions of illumination as required. The old open arc lamp of low voltage and high amperage was extremely efficient, and it has been found difficult to equal its performance with the modern enclosed arc lamp when judged from the basis of efficiency alone. Nevertheless, the enclosed arc has almost completely supplanted the open type of arc.

There are two reasons for this, one of which is the lower rate at which the enclosed arc carbons are consumed, which admits of a long period of burning between trims. This advantage has been found so great that in nearly every case the enclosed arc has been adopted mainly on account of its infrequent attendance required.

The other desirable feature of the enclosed arc lamp is the voltage at which this lamp may be operated, which allows of connecting the lamp directly to 110 and 220 volt circuits. In fact, the desirability of supplying the current at 220 volts was of such importance that 220 volt arc lamps were installed where considerable trouble was at first experienced from burnt-out resistance and fusing of globes; also, the light was not of as desirable a color as that of the 110 volt lamp. These faults have been remedied.

With the introduction of the Nernst lamp operating directly on 220 volt alternating current circuits the field of illumination, where a low-candle power unit is sufficient, and where a large territory must be covered, is readily supplied with this type of lamp. The high voltage at which the lamp burns adapts it to long secondary distributions, and the feature of operating on an alternating current is especially suitable for shops and yards covering a large territory, since the alternating current can be supplied at a high voltage from the central station to many distributing points, and then stepped down to the 220 volts required by the lamp. This lamp gives excellent service for isolated stations covering large territory.

The incandescent lamp with carbon filament, when made in high candle-power where a long filament is used, is also highly efficient, both from the standpoint of watts per candle-power and in the permissible voltage of distribution. Results have been secured with this type of lamp approaching the enclosed arc lamp for general illumination with moderately large units. The lamp is also desirable, as, like the Nernst lamp, it gives a downward light without shadows, a feature of decided advantage, as the shadows cast by arc lamps are usually objectionable, though this difficulty with the arc lamp has been largely overcome by the selection of suitable reflectors, or by installing opalescent outer globes of the closed-base type.

Lately the tantalum lamp has been developed, and has been found to give a high efficiency in moderately sized units at a low voltage. The length of filament of this lamp gives a light of large volume, and high candle-power per watt consumed. Judging by the length of filament, it would seem, however, that this type of lamp is better adapted to low voltages and would therefore not be applicable to large buildings of low density of illumination, if compared with lamps burning at equal efficiencies. The efficiency is so high, however, that the small amount of current compensates for the low voltage, in that the actual percentage drop in potential from the main switch to the last lamp is small.

A still later form of lamp has been developed in which the Tungsten filament is utilized. When operated on a series circuit the efficiency is as good as one and a quarter to one and a half watts per candle, and the life is 1000 hours. These results are certainly remarkable, and if they can be duplicated at a higher voltage on multiple circuits leave little to be desired. It must be remembered that the old form of incandescent lamp with carbon filament gives extremely good results when of high candle-power and low voltage, and burning on the series circuit at a constant amperage, so that the field in which the Tungsten lamp is introduced is already fairly well covered.

While the incandescent lamp and smaller units have been developed to include more intenselighting until they approach the carbon arc lamps the larger units have also been developed to larger and larger sizes. Notable among these is the flame-arc lamp. There are several types of these, many of which are desirable for installations requiring moderately high voltages, while all give extremely efficient results at low voltages. The color of the lamp is good. Its one feature, which may be objectionable, is the necessity for more frequent trimming than is required by the enclosed arc.

The mercury arc lamp is also making a strong appeal to the illuminating engineer on account of its high efficiency and low attendance cost. Its greatest objection is the color of illumination, though where the actual color of the object viewed is of minor importance the high efficiency and low attendance cost of this lamp make it a strong competitor for public favor, such as in drafting-rooms and machine-shops, where it is important to make accurate measurements of distance, and a comparison of color values is not required.

In selecting a form of illuminant there are three things to consider: first—the efficiency of the lamp considered as a whole in watts per candle-power measured at the lamp terminals; second—the attendance required to keep the lamp in proper condition; and, third—the voltage allowable at the lamp terminals. In this last item should be included the question of whether an alternating current or a direct current can be used for supplying the energy, also the frequency at which the illumination is uniform. The frequency at which lighting is objectionable does not depend entirely on the frequency of the circuit, since the filament of incandescent lamps and the vapor of arc lamps introduces a time element in smoothing out the variations of light intensity. A lamp with a thick, short filament of high candle-power when operated at a low efficiency gives better results at a low frequency than can be obtained with a lamp made from the same filament material and operated at a higher efficiency. If we take the ordinary carbon filament incandescent lamp and operate it at a rate of 4 to 5 watts per candle-power the lighting on a 25-cycle circuit is not as objectionable as the same lamp when connected to a higher voltage to obtain an efficiency of 3.1 watts per candle-power. It would, therefore, seem that a lamp to be desirable on a low frequency circuit must, of necessity, have poor efficiency. To obtain high efficiency the filament is subjected to a high current density, maintaining a high temperature which gives an intense white light. On the other hand, to neutralize the effect of variations in frequency it is apparently necessary to run the lamp at a low-current density with consequent poor efficiency.

What is needed at the present time is a lamp to give a white light with a low-rate of watt consumption per candle-power, that requires but little attendance, and that can be operated on a circuit of high voltage, at least at 220 volts, and preferably at 440 volts. It is also desirable to have this type of lamp operative on the alternating current circuit at a low frequency. This is the ideal to be attained, and while lamps of different makes excel in some one particular, no one lamp excels in all of these requirements.

Photometry

THE incandescent lamp manufacturers make a practice of supplying standard 16-candle-power incandescent lamps for use in testing the light intensity of incandescent lamps. These standard lamps are carefully calibrated with known standards and may be accepted as correct within the limits of the customary personal error which occurs in making photometrical measurements. The greatest accuracy is obtained by comparing lamps of approximately equal candle-power, since the scale on which the candle-power is read has its widest calibration midway between the standard and the lamp tested.

The wide space between divisions at the central part of the scale has one disadvantage, however, in that the divisions admit of reading much closer than it is possible to make a measurement with a photometer. This fact has led to some distrust of the measurements made because it is almost impossible to make two readings by different persons or by the same person check when a sufficient interval has elapsed. It would be much better if the scale of the photometer did not permit of such accurate readings at this point, since the readings, as made from the screen, would then check approximately. The difficulty is that such light measurements are relative values, and cannot be measured in exact amounts. If we could state the light intensity in terms of length, mass or time we would know definitely just what was stated and could always devise measuring instruments to read as accurately as desired.

Owing to the photometric action of the light rays, a measure can be obtained of the light intensity by allowing the light to act for a definite length of time on a photographic plate of given strength of emulsion. The weight of silver deposited by stated methods of development and fixation could then be measured in terms of its mass, so that the action of the light is definitely reduced to exact figures. Of course, the errors of observation and in manipulating the plate are liable to be much greater than the errors of personal observation now incurred by the present method of making photometrical measurements. However, this method has the desirable feature of reducing the measurement to an exact amount at the time of obtaining the final result, and the question is simply one of following definitely stated rules; the measurement is not one in which the personal opinion of the observer comes into play; he must follow the stated rules as specified.

Photometers are made for measuring the reflection from a surface placed within the illuminated area, the surface being placed normal to a line drawn from the source of light to its center and being made of specified material, generally dull white. These photometers permit of measuring the illumination from arc lamps, Nernst lamps and other lamps which are of too strong tensity to be compared with the ordinary incandescent lamp. At first thought it would seem to be impossible to make a measurement with this form of photometer, since the observer must be between the light and the surface from which the light is reflected, and should, therefore, cast a shadow over the surface. Actually, however, a measurement is readily made without incurring an error from shadows cast by the observer.

The distance between the surface and the point from which the measurement is made is not important in this case. This is due to the fact that the surface is large and the intensity of light reflected from it does not diminish, except at considerable distances. This is a point which is generally not taken into consideration when using the older forms of photometers, that is, the size of the source of light is not considered. While it is perfectly true that the light intensity emanating from a point diminishes as the square of the distance from the point the light intensity from a lamp of appreciable dimensions does not diminish as the square of the distance from the source of light, except at a distance of several times the lamp dimensions. Errors from neglecting this fact will creep into measurements where the size of the light is not considered by taking the measurements at a sufficient distance away. Lamps of the mercury arc and tubular type, where the lamp has a length of two or three feet, can be measured to give but a very small candle-power when the measurement is made at a distance of two or three feet away. If the distance at which the measurement is made be increased the light intensity will be found to be reduced but slightly, until the distance is increased to ten or fifteen feet, from which point the light will be found to reduce as the square of the distance. Obviously there is a slight error in measuring the strength of an incandescent lamp having a height of four or five inches when the measurement is made but ten or twelve inches away, and results can be obtained entirely at variance with the actual facts.

Another possible method of measuring the strength of light can be accomplished by using the photographic exposure meters now in the market. These meters at the present time are only applicable to the measurement of the strength of light from the sun as reflected by clouds or other strong sources of light. They consist of a piece of sensitized paper, which is changed in color by the action of the light, and the time from which the paper is exposed to the time at which it is turned to a shade to match a colored sample supplied with the meter is measured, thence by comparison of the measured time with a table the relative strength of light is determined. Arc lamps can be readily measured in terms, of their actinic value and such measurements would be of value if it were not for the fact that the violet rays of light have a greater effect than the red rays of light. Also, these lamps are undesirable when the violet rays predominate. Such a measure, therefore, does not give a fair valuation of the strength of light, except for photographic purposes.

Chances in the Patent Field

IN probably no other field of invention is there so much piracy as in the electrical industry. While this condition is undoubtedly due to the rapid development of the art itself, much stress must be laid on the *scarcity of good engineers,* the *failure to maintain an efficient patent department* and the known fact that suits will drag through tedious legal processes.

The manufacturer is dependent on his engineer for advice, and where there is a close similarity of design or the use of a part which has been only vaguely covered in a specification, then is time to carefully examine the specification. It may cost much to overlook a clause or minor claim.

Smaller companies should not depend on their engineers any more than a business corporation depends on its legal adviser. It is wise to bring into consultation the best legal and engineering talent which can be obtained and then to proceed with caution. Failure to do so has frequently been disastrous.

We speak of those manufacturers who are honestly striving to enlarge their commercial engineering field. Of those who are taking chances in the patent field, little need be said. They cannot expect to remain in a business where their profits are derived from the sale of litigious apparatus.

The truths just set forth have been strikingly illustrated by a recent decision awarding one of the large companies $133,000 as compensation for damages done by one of the smaller companies in infringing transformer patents.

Method of Plotting the Hysteresis Loop for Iron

A PAPER on the subject of plotting the hysteresis loop for iron, by Gisbert Kapp, is reprinted in full on another page of this issue. This article will be of immense interest to those engaged in transformer manufacture and in other industries where the magnetic properties of iron are of importance.

In applying any formula containing a time constant of an electric circuit, the effect of secondary circuits must be taken into consideration. The complete formula for a primary and one secondary circuit is

$$\frac{d}{dt}(Li+Mj)+Ri=E$$

where L represents the coefficient of self-induction of the primary and M represents the coefficient of induction in the primary due to unit current in the secondary. The primary current is represented by i and the secondary current by j. The primary resistance is represented by R. The applied voltage is represented by E.

The solution of equations involving these unknown quantities gives,

$$i=\frac{E}{L\left(1+\frac{RN}{LS}\right)^2}e^{-\frac{R}{L}\frac{1}{1+\frac{RN}{LS}}t}$$

where N represents the coefficient of self-induction of the secondary and e is the base of the hyperbolic system of logarithms. The value of $\frac{RN}{LS}$ is always positive and real. The current will therefore increase more rapidly with a secondary circuit than when none is present.

It is therefore important that all conducting materials be excluded from the proximity of the testing coil and that the core of iron tested be thoroughly laminated.

Moreover, it is important that the winding of the test-coil be thoroughly insulated as otherwise circuits will be produced between turns that will have the effect of reducing the time constant.

Selling Current

WITH this number is inaugurated a department which will be headed "Selling Current." Items of interest to central station managers, to solicitors and to others engaged in commercial work and connected with electric-light and power stations will be printed in this department. We have been particularly fortunate in securing several articles for this department written by Mr. C. N. Jackson, who has had wide experience in this line of work.

In these articles personal experiences will be given with reasons for success or failure in dealing with different customers, and a course of procedure is recommended for dealing with a customer under similar circumstances.

All items referring to selling current with methods for the increase in this sale both with regard to light and power will be treated fully in this department and subscribers will be kept informed of the latest methods in vogue.

Transmission Line Calculations

THERE have been devised from time to time numerous formulæ, tables and charts to simplify the calculations involved in designing alternating-current transmission lines. While these devices undoubtedly simplify the calculations in certain particular cases, none of them possess at the same time the comprehensiveness, simplicity and accuracy of the formulæ and tables given on one of the following pages.

A concise definition of each symbol involved is given and the quantities to be determined then expressed—*i. e.,* the weight of conductor, the cross-section of conductors, the power loss and pressure drop—in simple formulæ requiring for their solution the minimum mental effort.

The line capacity is considered as introducing a correction term in the values of the per cent. power loss and the per cent. pressure drop, as determined by first neglecting the presence of the capacity effect. The formulæ derived for this correction term are approximate only, but as the correction term is usually small, the error in the true pressure drop or power loss is, in ordinary cases, negligible. The approximate expression for the decrease in the per cent. pressure drop is a very simple one, being merely the product of the line reactance times the capacity susceptance times 100, and is therefore independent of the value of the load and the power factor.

The quantity "capacity susceptance," in spite of its name, really represents a very simple physical quantity—that is, it is the ratio of the charging current to the line pressure for a single-phase line. A table of values of this quantity for various sizes of wires, distances apart of wires, and frequencies is also given.

The Calculation of Transmission Lines

HAROLD PENDER, Ph. D.

TWO problems that every electrical engineer frequently has to solve are: (1) the determination of the size and weight of conductor required to transmit a given amount of power with a given line loss, and the reverse of this; (2) to determine the power loss and pressure drop (or volts lost) in transmitting a given amount of power over a line of known constants. For direct-current transmission the calculations involved in the solution of these problems are comparatively simple, but in the case of alternating currents the presence of line reactance and capacity and the phase relation of current and pressure introduce a number of complex factors. Numerous formulæ, charts and tables have been devised to simplify the arithmetical computations involved, but none of the methods with which the author is familiar possess the three essential qualities of simplicity, accuracy and comprehensiveness.

The formulæ and tables given have been devised to fulfil these conditions. The formulæ have been put in the simplest shape possible and care has been taken to give a concise definition of each symbol involved. The constants entering into the formulæ are given for both copper and aluminum and for both three-phase and single-phase systems; for direct-current distribution the formulæ for weight, cross-section and power loss are the same as for a single-phase system of unity power factor and the per cent. pressure drop is always equal to the present power lost. The formulæ are all expressed in terms of the power delivered; this eliminates the calculation of the current, which is unnecessary for purpose on hand.* The tables give all the data necessary for the complete solution of any case of transmission likely to arise in practice, whether single phase or three phase, both for copper and for aluminum conductors.

Let

E = pressure between adjacent wires at receiving end in volts.

W = power delivered in kilowatts.

k = power-factor of the load expressed as a decimal fraction.

A = cross-section of each wire in millions of circular mils.

w = total weight of conductors in pounds.

l = length of circuit (length of each wire) in feet.

R = resistance of each wire in ohms.

Q = per cent. loss in terms of delivered power.

P = per cent. pressure drop in terms of delivered pressure.

Put

$$F = \frac{lW}{(kE)^2}$$

The *per cent. pressure drop* for either single or three-phase system, and for any kind of conductor is

$$P = MQ + NQ^2$$

		Single Phase		Three Phase	
		Copper†	Aluminum‡	Copper†	Aluminum‡
Given E, W, k, l, and Q, then: Total weight of conductor.	w =	$\frac{12.6\,Fl}{Q}$	$\frac{6.11\,Fl}{Q}$	$\frac{9.45\,Fl}{Q}$	$\frac{4.58\,Fl}{Q}$
Cross section in million CM.	A =	$\frac{2.08\,F}{Q}$	$\frac{3.34\,F}{Q}$	$\frac{1.04\,F}{Q}$	$\frac{1.67\,F}{Q}$
Given E, W, k, l, and A, then: Per cent. power loss.	Q =	$\frac{2.08\,F}{A}$	$\frac{3.34\,F}{A}$	$\frac{1.04\,F}{A}$	$\frac{1.67\,F}{A}$
Given E, W, k and R, then: Per cent. power loss.	Q =	$2\times10^5\frac{RW}{(kE)^2}$		$10^5\frac{RW}{(kE)^2}$	

† Temperature 20° C., conductivity 100 per cent.
‡ Temperature 20° C., conductivity 62 per cent.

Where M and N are constants depending on the power-factor (k) and the ratio (E) of the line reactance to the line resistance, this ratio I have called the "reactance-factor"; tables I and II give the values of the constants M and N for various values of k and E. To a close approximation, except when the power-factor is nearly unity, or the receiver current is leading, the term NQ^2 may be neglected, *i. e.*, in most practical cases $P = MQ$. The complete expression $P = MQ + NQ^2$ is exact in all cases for a 10 per cent. power loss; it is in error less than 3 per cent. for any value of P less than 30; in any case likely to arise in practice the discrepancy is less than 1 per cent. in the value of P. (The exact expression for P in terms of Q is

$$P = 100 - \sqrt{10^4 + 200\,(1 + Et)\,k^2Q + (1 + E^2)k^2Q^2}$$

where t is the tangent corresponding to the cosine k.)

Table III gives the value of the "reactance-factor" for various sizes of wire spaced various distances apart, also the corresponding cross-section of conductor in millions of circular mils, and the resistance per 1000 feet of copper wire (100 per cent. conductivity) and of aluminum wire (62 per cent. conductivity), all at a temperature of 20 degrees Centigrade.

NUMERICAL EXAMPLES.

1. To find the weight and cross-section of aluminum required for a three-phase line in order to transmit, with a power loss of 10 per cent., 15,000 kilowatts a distance of 45 miles (238,000 feet), the power-factor at the receiving end being 90 per cent., and the pressure at the receiving end 60,000 volts between wires.

We have

E = 60,000
W = 15,000
k = .9
l = 238,000
Q = 10

$$F = \frac{238{,}000 \times 15{,}000}{(.9 \times 60{,}000)^2} = 1.22$$

then total weight of aluminum

$$w = \frac{4.58 \times 1.22 \times 238{,}000}{10} = 133{,}000 \text{ lbs.}$$

*The amperes per wire in a single-phase system is $\frac{W\times10^3}{kE}$ and in a three-phase system $\frac{578W}{kE}$ using the symbols in the text.

Cross-section of wire in million CM

$$A = \frac{1.67 \times 1.22}{10} = .204$$

The nearest size of wire is No. 0000, which has a cross-section of .212 million CM (table III). The power loss will then be

$$\frac{.204}{.212} \times 10 = 9.63$$

per cent. instead of 10 per cent., and the weight of conductor will be

$$\frac{.212}{.204} \times 133{,}000 = 138{,}000$$

pounds instead of 133,000 pounds.

Example 2. A load of 7500 kilowatts is to be delivered at 60,000 volts to a receiver having a 90 per cent. power-factor over a three-phase line of No. 00 hemp cored copper cable (diameter 0.45 inches), 140 miles (739,000 feet) long; frequency 60 cycles, wires spaced 8 feet apart.

From table III it is found that the resistance per 1000 feet of No. 00 copper wire is .0778 ohms; the resistance of each wire is then

$$R = .0778 \times 739 = 57.5$$

The reactance-factor at 60 cycles

$$E = 3.2 \times .6 = 1.92$$

We also have

$$E = 60{,}000$$
$$W = 7500$$
$$k = .9$$

Therefore, neglecting the capacity of the line, per cent. power loss

$$Q = 10^5 \frac{57.5 \times 7500}{(9 \times 60.000)^2} = 14.8$$

From tables I and II, corresponding to a reactance-factor of 1.92 and a power-factor of 90 per cent. (current lagging)

$$M = 1.55$$
$$N = .006$$

Therefore, per cent. pressure drop

$$P = 1.55 \times 14.8 + .006 \times \overline{14.8}^2 = 24.2$$

EFFECT OF LINE CAPACITY.

The effect of the capacity of the line is to reduce the pressure drop, *i. e.*, better the regulation, and to decrease or increase the power loss, depending on the load and the power-factor of the receiver. Let

$$b = 2\pi f G$$

where C is the capacity of the condenser formed by any pair of wires of the line, and f is the frequency; b is called the capacity susceptance of

TABLE I—VALUES OF M.

Reactance Factors = E	Power Factors of Receiver: Current Leading 90	95	98	Current Lagging 100	98	95	90	85	80	70
0.0	.81	.90	.96	1.00	.95	.90	.81	.72	.64	.49
0.1	.77	.87	.94	1.00	.98	.93	.85	.76	.69	.54
0.2	.73	.84	.92	1.00	1.00	.96	.89	.81	.74	.59
0.3	.69	.81	.90	1.00	1.02	.99	.93	.86	.79	.64
0.4	.65	.78	.88	1.00	1.04	1.02	.97	.90	.83	.69
0.5	.61	.75	.86	1.00	1.06	1.05	1.01	.94	.88	.74
0.6	.58	.78	.84	1.00	1.08	1.08	1.05	.99	.93	.79
0.7	.54	.69	.82	1.00	1.10	1.11	1.09	1.03	.98	.84
0.8	.50	.66	.80	1.00	1.12	1.14	1.13	1.08	1.02	.89
0.9	.46	.63	.78	1.00	1.14	1.17	1.17	1.13	1.07	.94
1.0	.42	.61	.77	1.00	1.16	1.20	1.20	1.17	1.12	.99
1.1	.38	.58	.75	1.00	1.18	1.23	1.24	1.21	1.17	1.04
1.2	.34	.55	.73	1.00	1.19	1.26	1.28	1.26	1.22	1.09
1.3	.30	.52	.71	1.00	1.21	1.29	1.32	1.31	1.27	1.14
1.4	.26	.49	.69	1.00	1.23	1.32	1.36	1.35	1.31	1.19
1.5	.22	.46	.67	1.00	1.25	1.35	1.40	1.39	1.36	1.24
1.6	.18	.43	.65	1.00	1.27	1.38	1.44	1.44	1.41	1.29
1.7	.14	.40	.63	1.00	1.29	1.41	1.48	1.48	1.46	1.34
1.8	.10	.37	.61	1.00	1.31	1.44	1.51	1.53	1.50	1.39
1.9	.07	.34	.59	1.00	1.33	1.47	1.55	1.58	1.55	1.44
2.0	.03	.31	.57	1.00	1.35	1.50	1.59	1.62	1.60	1.49
2.1	-.01	.28	.55	1.00	1.37	1.53	1.63	1.66	1.65	1.54
2.2	-.05	.25	.53	1.00	1.39	1.56	1.67	1.70	1.70	1.59
2.3	-.09	.22	.51	1.00	1.41	1.59	1.71	1.75	1.75	1.64
2.4	-.13	.19	.49	1.00	1.43	1.62	1.75	1.80	1.79	1.69
2.5	-.17	.16	.47	1.00	1.45	1.64	1.79	1.84	1.84	1.74
2.6	-.21	.13	.45	1.00	1.47	1.67	1.83	1.88	1.89	1.79
2.7	-.25	.30	.43	1.00	1.49	1.70	1.87	1.93	1.94	1.84
2.8	-.29	.07	.41	1.00	1.51	1.73	1.91	1.98	1.98	1.89
2.9	-.33	.04	.39	1.00	1.53	1.76	1.96	2.02	2.03	1.94
3.0	-.36	-.01	.37	1.00	1.55	1.79	1.99	2.06	2.08	1.99
3.1	-.40	-.02	.36	1.00	1.57	1.82	2.03	2.11	2.13	2.04
3.2	-.44	-.05	.34	1.00	1.58	1.85	2.04	2.15	2.18	2.09
3.3	-.48	-.08	.32	1.00	1.60	1.88	2.10	2.20	2.23	2.14
3.4	-.52	-.11	.30	1.00	1.62	1.91	2.14	2.24	2.27	2.19
3.5	-.56	-.14	.28	1.00	1.64	1.94	2.18	2.29	2.32	2.24

TABLE II—VALUES OF N.

Reactance Factors = E	Power Factors of Receiver. Current Leading 90	95	98	Current Lagging 100	98	95	90	85	80	70
0.0	.001	.001	.000	.000	.000	.001	.001	.001	.001	.002
0.1	.001	.001	.000	.000	.000	.000	.000	.001	.001	.001
0.2	.002	.001	.001	.000	.000	.000	.000	.001	.001	.001
0.3	.002	.002	.001	.000	.000	.000	.000	.000	.000	.001
0.4	.003	.002	.002	.001	.000	.000	.000	.000	.000	.000
0.5	.003	.003	.002	.001	.000	.000	.000	.000	.000	.000
0.6	.003	.003	.003	.002	.000	.000	.000	.000	.000	.000
0.7	.004	.004	.004	.002	.001	.000	.000	.000	.000	.000
0.8	.005	.005	.005	.003	.001	.001	.000	.000	.000	.000
0.9	.006	.006	.006	.004	.002	.001	.001	.000	.000	.000
1.0	.007	.006	.006	.005	.002	.002	.001	.001	.000	.000
1.1	.008	.007	.007	.006	.003	.002	.001	.001	.000	.000
1.2	.009	.008	.008	.007	.004	.003	.002	.001	.000	.000
1.3	.010	.010	.009	.008	.005	.003	.002	.001	.000	.000
1.4	.011	.011	.011	.009	.006	.004	.003	.001	.001	.000
1.5	.013	.013	.012	.010	.007	.005	.003	.002	.001	.000
1.6	.014	.014	.014	.011	.008	.006	.004	.002	.001	.000
1.7	.016	.016	.015	.013	.009	.007	.004	.003	.002	.000
1.8	.017	.018	.017	.015	.011	.008	.005	.003	.002	.000
1.9	.018	.019	.019	.016	.012	.009	.006	.003	.002	.000
2.0	.020	.021	.021	.018	.013	.010	.006	.004	.003	.001
2.1	.022	.023	.023	.020	.015	.011	.007	.005	.003	.001
2.2	.023	.025	.025	.022	.016	.012	.008	.006	.003	.001
2.3	.025	.027	.027	.024	.017	.014	.009	.006	.004	.002
2.4	.027	.029	.030	.026	.019	.015	.010	.007	.005	.002
2.5	.029	.031	.032	.028	.021	.017	.011	.008	.005	.002
2.6	.032	.034	.034	.030	.023	.018	.012	.009	.006	.003
2.7	.034	.036	.037	.033	.024	.020	.013	.010	.006	.003
2.8	.036	.039	.040	.035	.026	.021	.015	.010	.007	.003
2.9	.038	.041	.042	.037	.028	.023	.016	.011	.008	.004
3.0	.040	.044	.045	.040	.030	.024	.018	.012	.009	.004
3.1	.042	.046	.047	.042	.033	.026	.019	.013	.009	.004
3.2	.045	.049	.050	.045	.035	.028	.020	.014	.010	.005
3.3	.048	.052	.053	.048	.038	.030	.021	.015	.011	.005
3.4	.051	.055	.056	.051	.040	.032	.023	.017	.012	.006
3.5	.053	.059	.060	.054	.043	.034	.024	.018	.013	.006

the line (for a single-phase line the charging current is bE; for a three-phase line the charging current per wire is 1.155bE)

Put

$$a = 100bR$$

and

$$t = \frac{\sqrt{1-k^2}}{k}$$

(the tangent corresponding to the cosine k)

Then

Single phase decrease in per cent. pressure drop

$$p = \frac{aE}{2}$$

Three phase decrease in per cent. pressure drop

$$aE$$

Single phase decrease in per cent. power loss

$$q = at - \frac{a^2}{2k^2Q}$$

Three phase decrease in per cent. power loss

$$2\ at - \frac{a^2}{k^2Q}$$

The true regulation of a line having capacity is then P—p, and the true per cent. power loss is Q—q. The change in the regulation is independent of the load and the power-factor, the per cent. power loss varies with these quantities. (These formulæ are deduced on the assumption that the line capacity can be represented by a condenser of half the capacity of line shunted across the line at each end; they are, therefore, approximate only, but are sufficiently accurate for practical purposes.)

Table IV gives the values of the capacity susceptance per 1000 feet of circuit for various sizes of wire spaced various distances apart for a frequency of 100 cycles per second; the values for other frequencies are directly proportional.

Example: To find the effect of the line capacity in example 2 given above.

From table IV the capacity susceptance per 1000 feet corresponding to a diameter of .45 inch and 60 cycles per second is $.88 \times .6 \times 10^{-6} = .528 \times 10^{-6}$, therefore

$$b = .528 \times 739 \times 10^{-6} = .000391$$

and

$$a = .100 \times .000391 \times 57.5 = 2.25$$

$$t = \frac{\sqrt{1-.81}}{.9} = .485$$

therefore, decrease in per cent. pressure loss is

$$p = 2.25 \times 1.92 = 4.3$$

and decrease in per cent. power loss is

$$q = 2 \times 2.25 \times .485 - \frac{2.25}{.81 \times 14.8} = 1.8$$

Hence, the true per cent. pressure drop is

$$24.2 - 4.3 = 19.9$$

and the true power loss is

$$14.8 - 1.8 = 13.0$$

TWO OR MORE CIRCUITS IN SERIES.

The above formulæ and tables are also applicable to the case of two or more circuits in series, *i. e.*, a transmission line and transformer, if we put

$$R = R_1 + R_2 + \ldots\ldots$$

$$E = \frac{R_1E_1 + R_2E_2 + \ldots\ldots}{R}$$

where R_1, R_2, etc., are the resistances of the separate circuits and E_1, E_2, etc., are the reactance factors of the separate circuits.

TABLE III—CROSS SECTION, RESISTANCE AND REACTANCE FACTORS.

Temperature 20 Degrees C.

Reactance factors are directly proportional to frequency and to conductivity:
For Copper Wire and 25 Cycles divide the reactance factors given below by 4.
For Copper Wire and 60 Cycles multiply the reactance factors given below by 0.6.
For Aluminum and 25 Cycles multiply the reactance factors given below by 0.155.
For Aluminum and 60 Cycles multiply the reactance factors given below by 0.372.

Number	Cross Section Millions of CM.	Ohms per 1000 ft. at 20° C.		Reactance factors for 100 per cent. Conductivity and 100 Cycles per Second — Distance Apart of Wires in Feet							
		Copper	Aluminum	1	2	3	4	5	6	7	8
	.500	.0207	.0334	6.97	8.26	8.99	9.56	9.94	10.28	10.57	10.84
	.450	.0230	.0371	6.36	7.52	8.18	8.68	9.03	9.32	9.60	9.84
	.400	.0259	.0418	5.75	6.78	7.37	7.81	8.13	8.39	8.63	8.84
	.350	.0296	.0477	5.10	6.00	6.52	6.91	7.18	7.41	7.62	7.81
	.300	.0345	.0556	4.46	5.23	5.68	6.01	6.24	6.45	6.62	6.78
	.250	.0414	.0668	3.80	4.44	4.82	5.08	5.29	5.46	5.60	5.73
0000	.212	.0489	.0790	3.29	3.84	4.14	4.38	4.55	4.69	4.82	4.93
000	.168	.0617	.0995	2.68	3.11	3.36	3.54	3.67	3.78	3.88	3.97
00	.133	.0778	.125	2.18	2.52	2.72	2.86	2.97	3.06	3.13	3.20
0	.106	.0981	.158	1.93	2.05	2.20	2.32	2.40	2.47	2.53	2.59
1	.0837	.124	.200	1.44	1.66	1.78	1.87	1.94	2.00	2.04	2.09
2	.0663	.156	.252	1.17	1.34	1.44	1.51	1.56	1.61	1.65	1.68
3	.0526	.197	.318	.95	1.09	1.17	1.22	1.26	1.30	1.33	1.36
4	.0417	.248	.400	.78	.88	.94	.99	1.02	1.05	1.07	1.10
5	.0331	.313	.505	.63	.71	.76	.80	.82	.85	.87	.88
6	.0263	.394	.636	.51	.58	.61	.64	.66	.68	.70	.71

NOTE.—The above reactance factors are calculated for solid Wire; they are also practically correct for stranded cables and cables with hemp cores having the same cross sectional acrea of conductor.

TABLE IV—CAPACITY SUSCEPTANCE PER 1000 FEET OF TWO PARALLEL WIRES.

Frequency 100 Cycles Per Second.

Capacity susceptance is directly proportional to frequency:
For 25 Cycles per Second divide by 4.
For 60 Cycles per Second multiply by 0.6.

Size Wire Millions of CM. and B. & S.	Diameter in Inches.	Distance Apart of Wires in Feet							
		1	2	3	4	5	6	7	8
.500	.707	1.51x10^{-6}	1.26x10^{-6}	1.15x10^{-6}	1.08x10^{-6}	1.04x10^{-6}	1.00x10^{-6}	.97x10^{-6}	.95x10^{-6}
.450	.671	1.49	1.24	1.11	1.07	1.03	.99	.96	.94
.400	.632	1.46	1.23	1.12	1.06	1.02	.98	.95	.93
.350	.592	1.44	1.21	1.10	1.04	1.00	.97	.94	.92
.300	.547	1.41	1.19	1.09	1.03	.99	.96	.93	.91
.250	.500	1.37	1.16	1.07	1.02	.97	.92	.91	.90
0000	.460	1.34	1.14	1.05	1.00	.96	.93	.90	.88
000	.410	1.31	1.12	1.03	.98	.94	.91	.89	.87
00	.365	1.27	1.09	1.00	.96	.92	.89	.87	.85
0	.325	1.24	1.06	.99	.94	.90	.87	.85	.83
1	.289	1.20	1.04	.97	.92	.88	.86	.84	.82
2	.258	1.17	1.02	.95	.90	.86	.84	.82	.81
3	.229	1.14	.99	.93	.88	.84	.83	.81	.79
4	.204	1.11	.97	.91	.86	.83	.81	.79	.78
5	.184	1.09	.95	.89	.85	.82	.80	.78	.76
6	.162	1.06	.93	.87	.83	.80	.79	.77	.75

NOTE.—The capacity susceptances given in this table are for solid wires; a stranded wire of the same cross section has a capacity susceptance about 3 per cent. greater. For special cables having hemp cores use the susceptance corresponding to the actual diameter of the cable; the susceptance is a function of the diameter, not of the cross section.

On a Method of Plotting the Hysteresis Loop for Iron with an Application to a Transformer

DR. GISBERT KAPP

LET ϕ_0 be the flux in megalines produced by a continuous current of I_0 amperes through n turns of winding under an e.m.f. of e volts; then

$$e = RI_0.$$

If now e be suddenly reversed, then I will pass from its initial value $-I_0$ through zero to the final value $+I_0$. Any intermediate value of the current must obviously satisfy the equation

$$e = \frac{n}{100}\frac{d\phi}{dt} + RI. \quad \ldots \quad (1)$$

By observing t and I a time-current curve may be plotted, and from this curve and the known values of e and n the hysteresis loop giving ϕ as a function of I may be drawn. The arrangement of the test is shown in Fig. 1.

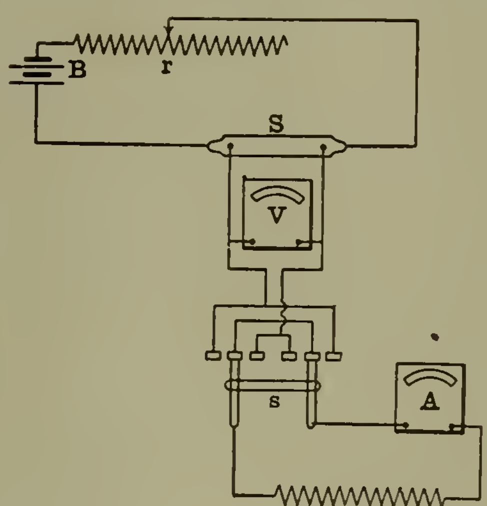

FIG. 1.

B is a source of current capable of giving from 50 to 100 times the magnetizing current I_0, which is passed through the transformer coil T. This current is taken off on the heavy shunt resistance S, between whose terminals the e.m.f. e is maintained and indicated on the voltmeter V. A is an ammeter with central zero and s a reversing switch. Care must be taken to have the contacts of this switch in good order, so that its resistance may be exactly the same in either position. S may conveniently be the shunt belonging to V, so that this instrument indicates the main current given by B, and A should be of sufficiently low resistance to reduce the loss of e.m.f. between S and T as much as possible.

To make the test, regulate r so that A indicates the desired magnetizing current I_0 and note the e.m.f. e. Then

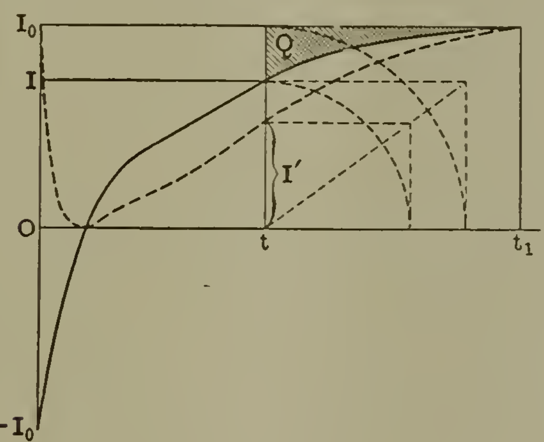

FIG. 2.

knock s sharply over, starting at the same time a stop-watch and noting the current indicated by A as a function of the time. The movement of the needle for values of I lying between $-I_0$ and zero is fairly quick, so that in this region single observations can only be taken by stopping the watch at the moment that the pointer passes a predetermined point on the scale. After the zero has been passed the movement becomes sufficiently slow for a continuous series of co-ordinate values of current and time to be noted. For transformers of similar type the speed of the needle is approximately proportional to the two-third power of the output. Thus, if with a 10 kw. transformer zero is reached in 4 seconds, it would be reached in about 6½ seconds with a 20 kw. and in about 16 seconds with an 80 kw. transformer. The shape of the time-current curve is of the character shown in Fig. 2. If there were no hysteresis loss, it would be a true logarithmic curve, but owing to the influence of hysteresis there is a depression in the upper part as shown.

From (1) we have

$$\frac{100}{n}(e - RI) = \frac{d\phi}{dt}$$

$$\frac{100R}{n}(I_0 dt - I dt) = d\phi,$$

$$\frac{100R}{n}(I_0 - I)dt = d\phi$$

Now $I_0 - I$ is the length of the ordinate between the curve and the $+I_0$ line, so that $\int(I_0 - I)dt$ is the area enclosed between the curve and this line. Integrating between the limits $-\phi_0$ and $+\phi_0$, to which correspond the times o and t_1, we find

$$2\phi_0 = \frac{100R}{n} Q_0, \quad \ldots \quad (2)$$

if by Q_0 we denote the whole area between the curve and its asymptote.

Integrating between the limits $-\phi_0$ and $+\phi$, to which correspond the times o and t, we find

$$\phi_0 + \phi = \frac{100R}{n}(Q_0 - Q). \quad . \quad (3)$$

By combining (2) and (3) we get

$$\phi = \frac{100R}{n}\left(\frac{Q_0}{2} - Q\right),$$

$$= \frac{100e}{nI_0}\left(\frac{Q_0}{2} - Q\right). \quad \ldots \quad (4)$$

Q is the shaded area in Fig. 2. Having fixed on a value of I, we find by planimeter the corresponding area Q, and from (4) the corresponding value of the flux ϕ.

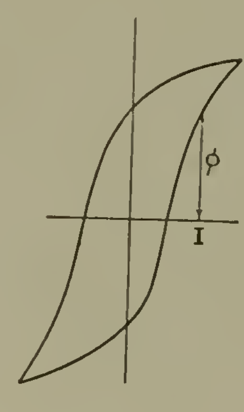

FIG. 3.

It is thus easy to find by means of a planimeter corresponding values of I and ϕ, and to plot these as shown in Fig. 3. The hysteretic energy per cycle is obviously

$$E = \frac{n}{100} \times \text{area of loop}.$$

If there are no joints in the carcass, and its cross-sectional dimensions are such as to make the induction the

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same in any part, the true B-H loop can, of course, be plotted, and the permeability as a function of the induction may also be found. In most cases, however, a knowledge of the exact shape of the B-H loop and of the permeability is of secondary importance; what we require is a knowledge of the hysteretic loss in the whole transformer, and this may be found graphically from Fig. 2 without even drawing Fig. 3.

The hysteretic energy absorbed by the carcass in one half-cycle is obviously the difference between

$$c\int_{0}^{t_1} I\,dt,$$

the total energy supplied, and

$$R\int_{0}^{t_1} I^2 dt,$$

the energy lost in copper heat. The latter quantity may be expressed in

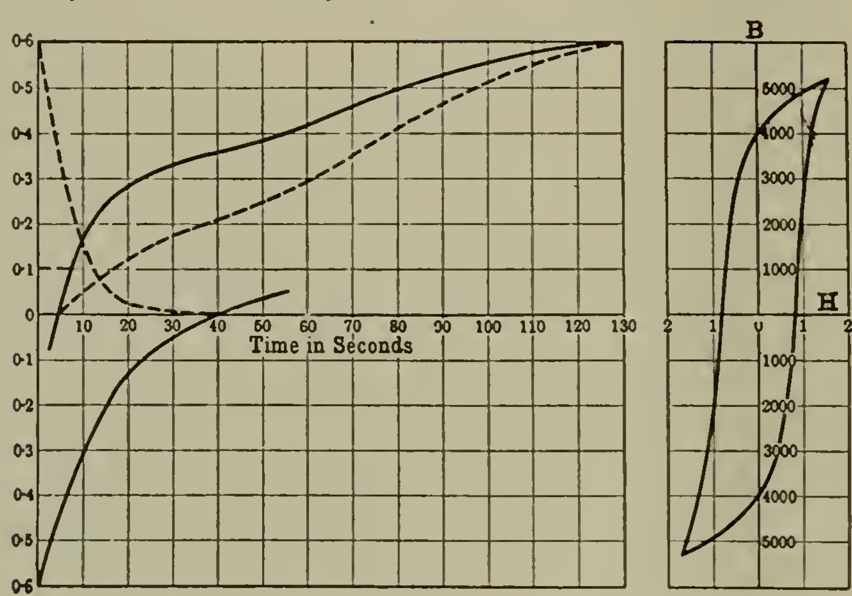


FIG. 4.

the form

$$RI_0\int_{0}^{t_1} I\frac{I}{I_0}dt \text{ or } c\int_{0}^{t_1} I'dt,$$

where $I'=I\frac{I}{I_0}$ can be determined graphically by the construction shown by dotted lines in Fig. 2. The hysteretic energy for one half-cycle is, therefore,

$$\frac{E}{2}=c\int_{0}^{t_1}(I-I')dt \text{ watt seconds.}$$

The integral is the area (expressed in coulombs) between the original time-current curve and the new I′ curve shown in a dotted line. The area is to be taken with reference to the sign of the current; that is to say, negative up to the point I=0 and positive for I >0. By planimetering the two areas and deducting that which is negative, we find

$$Q^h=\int_{0}^{t_1}(I-I')dt,$$

$$E=2cQ^h.$$

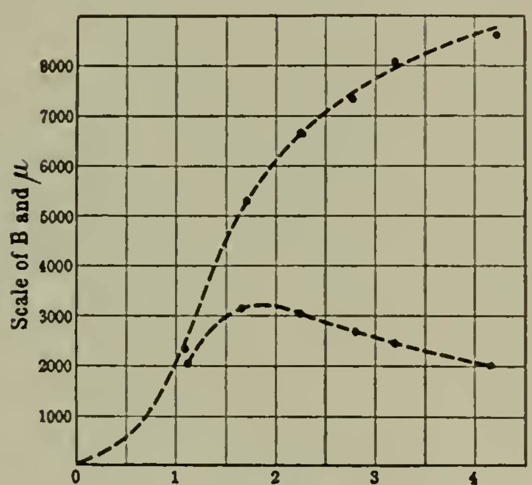


FIG. 5.

This construction applies to any transformer, whether it has joints or not, and whether the induction is the same throughout the magnetic path or not.

By way of illustration I give in Fig. 4 one of the time-current curves taken on a Westinghouse transformer of the shell type. The cross-sectional area of magnetic circuits is, in this case, constant throughout the path, namely, 200 sq. cm., its length is 53.8 cm., and as there are no butt joints (the carcass is built up with overlapping plates) it was possible in this case to find the true shape of the hysteretic

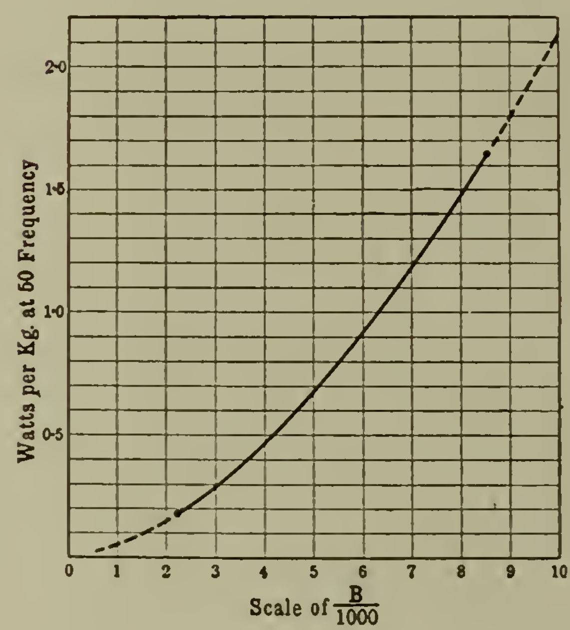


FIG. 6.

loop. This is drawn to the right of the time-current curve. In the test to which Fig. 4 refers n was 120, R=0.1, c=0.06, I_0=0.6.

To obtain greater accuracy in the planimetric measurements, the I and I′ curves up to zero are drawn to a time scale magnified tenfold. Tests were also made with values of I_0 ranging from 0.4 to 1.5, A corresponding to values of B from 2300 to 8600 respectively. From these tests the conjugate values of H, B, and μ are plotted in Fig. 5, while Fig. 6 gives the curve of hysteretic loss per kilogram of iron at 50 frequency.

Electrical Anomaly and Its Vector Solution

H. S. BAKER

It was found by accident that when a transformer had a constant alternating e.m.f. applied to its primary and a certain ohmic resistance applied across its secondary, that it took less primary current than when the secondary was open circuited.

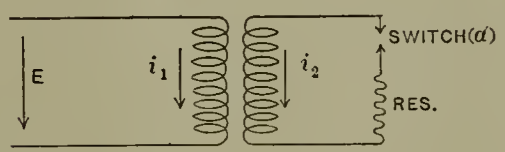


FIG. 1.

WIRING DIAGRAM.
TRANSFORMER CONSTANTS AND SYMBOLS.

Ratio of turns = 1 to 1.

Primary current $= i_1$.

Secondary current $= i_2$.

Primary resistance $= R_1 =$ say 15 ohms.

Total resistance of secondary, including external resistance $= R_2 =$ say 20 ohms.

E.m.f. applied to primary = E.

E.m.f. induced in primary or secondary $= c$ (for simplicity the leakage flux that links primary and not secondary is neglected).

Magnetizing current (with secondary open and with induced e.m.f. of c in primary) $= i_m$.

$$\frac{i_m}{c} \text{ is constant and known = say } \frac{1}{20}.$$

For simplicity, definite values of resistances and other data will be chosen and the vector analysis will show that with the resistance applied across the secondary the ratio of primary current to primary e.m.f. is less than with secondary open circuited. (See Figs. 1 and 2.)

Case 1. Leave secondary open and apply enough e.m.f. (E) to primary to make the value of induced e.m.f. (c) = 200 volts. Plot $c = 2$ inches. (Fig. 2.) From known ratio of i_m to c calculate $i_m = 200 \times 1/20 = 10$ amps. = 1 inch. Plot this i_m lagging c by 90°. Calculate the value of primary ohmic drop $i_m R_1 = 10 \times 15 = 150$ volts $= 1\frac{1}{2}$ inches. Plot this e.m.f. ($i_m R_1$) as shown, in step with i_m, and so that $i_m R_1$ and c will form a vector sum. Then their vector sum is $E_1 = P_1A = 2\frac{1}{2}$ inches = 250 volts.

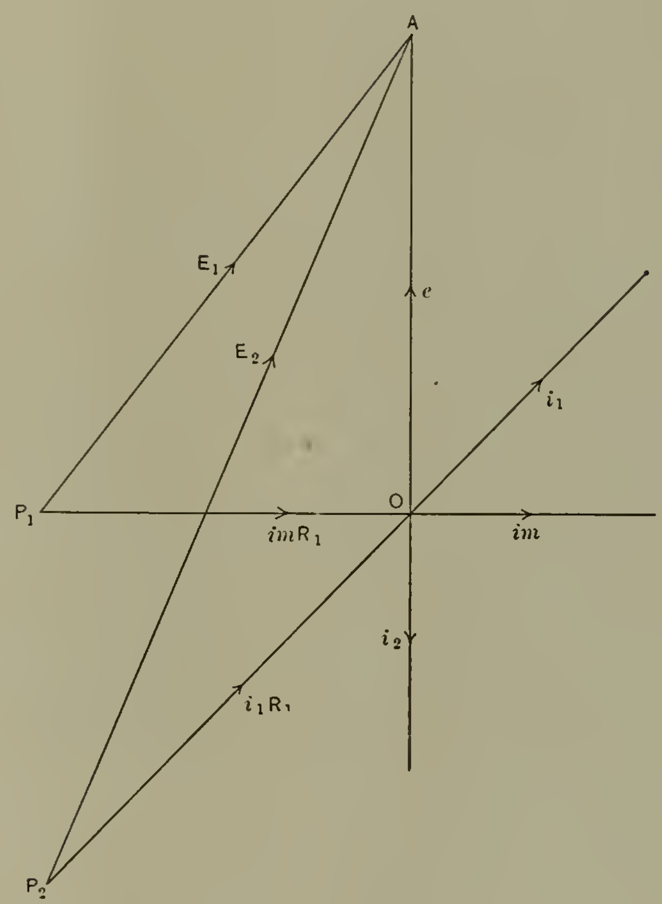


FIG. 2.

VECTOR DIAGRAM.
100 volts = 1 inch.
10 amps. = 1 inch.

Then the ratio

$$i_m \text{ to } E_1 = \frac{10}{250} = .04$$

Case 2. Close switch (a) and apply enough e.m.f. (E_2) to primary to make induced e.m.f. (c) = 200 volts.

Calculate

$$i_2 = \frac{c}{R_2} = \frac{200}{20} = 10 \text{ amps.}$$

Plot i_2 in opposition to $c = 1$ inch; i_m is same as before (being now only a component of primary current). Since the resultant of i_1 and i_2 is i_m, then plot i_1 so that i_m is the diagonal of the parallelogram having i_1 and i_2 for adjacent sides.

This gives i_1 as shown and it scales 1.41 inches = 14.1 amps. Calculate $i_1R_1 = 14.1 \times 15 = 212$ volts = 2.12 inches. Plot this in step with i_1 as shown. Now the applied e.m.f. (E_2) scales off 3.81 inches = 381 volts. Now the ratio of i_1 to E is

$$\frac{14.1}{381} = .037$$

which is less than in Case 1. If in Case 2 the same e.m.f. of 250 volts had been applied to primary as in Case 1 the primary current would have been $250 \times .037 = 9.25$ amps. instead of the 10 amps. that it was with secondary open. Of course, if a low resistance were applied across the secondary the primary current would be greater than with the secondary open.

Electric Locomotives—*Continued*

H. L. KIRKER

YOU know, of course, that Watt did not invent the steam engine, but commercialized it and thus made the steam locomotive possible. You do not know, perhaps, who made the electric locomotive possible. Well, it was Faraday. He laid the foundations seventy-five years ago. It was his discovery of magnetic induction and his conception of the idea of lines of magnetic force to explain his discovery that gave dynamic electricity to the industrial world. Up to the time of Faraday's discovery the only practical source of electric current was batteries. But when Faraday found that he could induce a current by mechanical means, and then explained his discovery in terms of lines of force, he gave the industrial world a working idea of electric forces—an idea that commercialized electricity.

Faraday was familiar with the magnetic properties of the electric current—he knew that a current deflects the compass needle, that parallel wires carrying currents in the same direction are pulled together and that parallel wires carrying currents in the opposite direction are pushed apart. Knowing this, his scientific instincts told him that since the electric current produces magnetic effect, why, magnetic effect should be able to produce electric current. Faraday had an extraordinary genius for research. He concentrated this genius on discovering a method of inducing currents, and in a remarkably short time he solved the problem.

What Faraday discovered was this—the movement of a parallel wire toward an electric current tends to set up in the wire a temporary opposing current, and the movement of the wire away tends to set up in the wire a temporary current of the same direction as the main, and that the temporary current ceases with the motion. We know, as stated, that currents flowing in the same direction tend to pull the wires together. We see, then, that the induction of a similar current by pulling the wires apart means work. This mechanical work is transformed into an electric current. We know, as stated, the currents flowing in the opposite direction tend to push the wires apart. We see, then, that the induction of an opposing current, by pushing the wires together, means work also. This mechanical work is transformed into electric current. The induction of an electric current then means work—it is the equivalent of overcoming resistance through space.

To explain how the motion of an idle wire toward or from a parallel wire carrying a current could set up a current in the idle wire, Faraday imagined the current to be encircled by magnetic lines of force. You know what lines of force are. You have seen pictures of steel magnets with lines of force emerging from the north pole, swinging around in broad loops to the south pole. See Fig. 2.

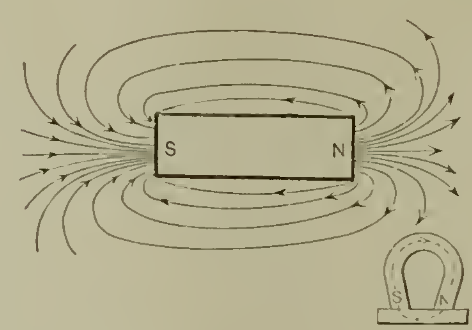


FIG. 2.

You know how the path of these lines can be mapped with iron filings, how the filings show the lines to form a complete magnetic circuit. You know how a bar of iron is drawn in to the poles of a horseshoe magnet, thereby completing the metallic path. Similar lines are supposed to encircle an electric current and give it its magnetic properties. See Fig. 3. When

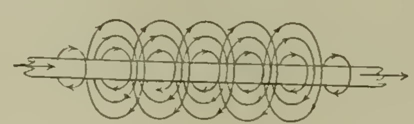


FIG. 3.

a parallel wire is moved toward a current-bearing wire it cuts across these lines of force. The cutting of the lines of force induces an electric pressure in the idle wire. The result is the same when the idle wire cuts the lines of force of a steel magnet. It is the cutting of the lines of force that induces the current. The dynamo is a machine for cutting lines of force: it is essentially a machine for moving wires across dense magnetic fields. We can easily assume the electric current to be encircled by magnetic lines of force. Starting with this assumption, we find by experiment that cutting these lines is a source of current. We then immediately inquire into the properties of the lines of force and want to know why it is that cutting these lines can induce current. We know that a compressed spring will recoil, and that compressed air will reproduce the motion that compressed it. Now, if we can explain current and lines of force in terms of our mechanical experience we should be able to see why cutting lines of force can induce current. It occurred to me that if I assumed the lines of force to represent a magnetic whirlpool with the current as its throat, why, I could explain not only the attraction and repulsion of parallel currents, but the induction of new currents as well.

You have seen little whirlpools with the gurgling hole down the center; you have seen dusty little whirlwinds with their long, twisting necks encircled by flying leaves; you have seen pictures of water-spouts and you know what cyclones and revolving storms are; now, with these in mind it will not be a difficult matter for you to imagine an electric current to be the axis of a revolving magnetic storm; the axis of the encircling magnetic whirlpool—to be the neck of the little magnetic whirlwind, the flexible shaft of these vortex rings of magnetism that dilate as the current increase and contract and vanish as the current dies away.

You can readily admit that two similar neighboring vortexes will tend to merge and revolve around a common axis—whether they be currents of water, currents of air, or currents of electricity. See Fig. 4. The pull-

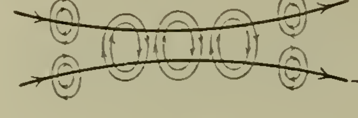


FIG. 4.

ing together of parallel electric circuits then is no more mysterious than a merging of two similar neighboring whirlwinds. Should these vortexes

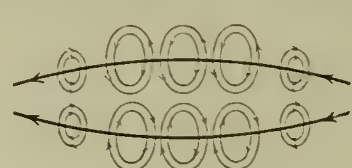


FIG. 5.

be whirling in opposite directions, you will also admit that they would be pushed apart. See Fig. 5.

(To be continued)

Electrically Operated Transfer Bridge

New York Central and Hudson River Railroad Company

TRANSFER bridges are installed at points where freight cars are transferred from water to land, or from land to water. These bridges are sometimes called lift bridges or float bridges, since their function is to lift or float the level of the tracks on land to match with the tracks on a ferry-boat.

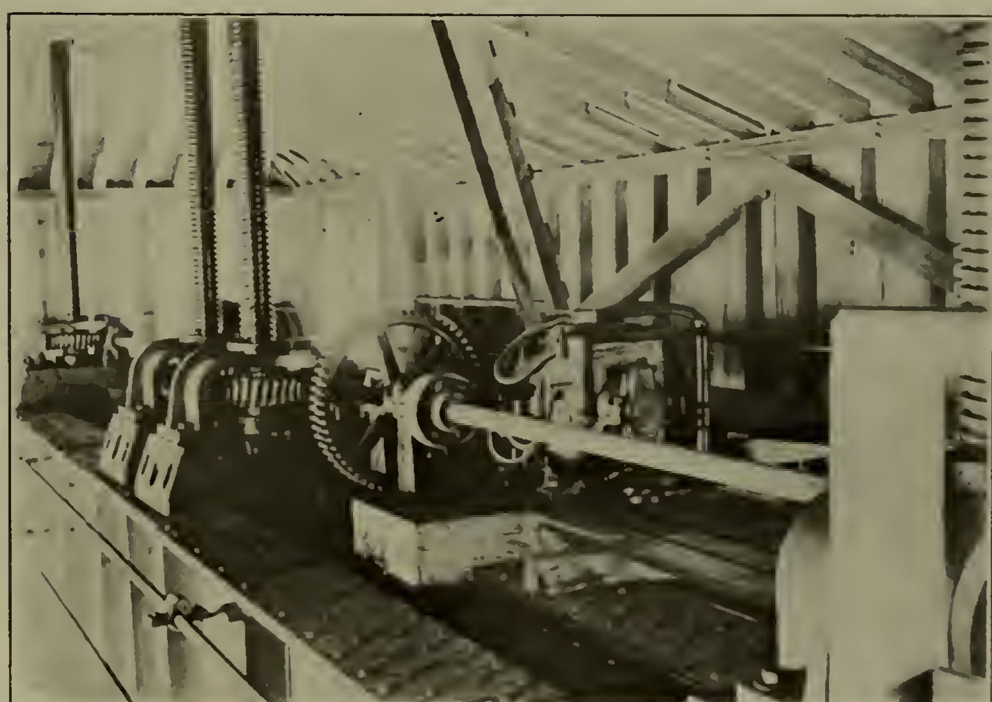
TRANSFER BRIDGE—LAND END.

The bridge consists of two parts—a main lift and an apron. The two parts are necessary in order to accurately align the tracks without depending on the flexibility of the tracks to too great an extent.

The particular bridge here illustrated is located at Sixty-second Street and the North River and is one of many in the New York Central freight yards about New York. It is one of the most recently equipped transfer bridges, and was therefore selected as most suitable for describing the equipment.

The motor equipment consists of two General Electric direct-current motors, the main lift being raised and lowered by a 35 horse-power railway type motor with normal load speed of 450 r.p.m. at 220 volts, and the apron being raised and lowered by a 7½ horse-power crane type of motor with normal speed of 650 r.p.m. at 220 volts.

Independent rheostatic control for each motor has been adopted as simplest; either motor may be operated independent of the other, or both may be operated together. The main lift motor is controlled by a type R-27 controller and the smaller motor is controlled by a type R-28 controller. Motors and controllers are entirely enclosed types as is necessary in damp locations on water fronts.



MAIN LIFT MOTOR.

The mechanical equipment has been developed from results secured with numerous bridges or lifts of this type. The main lift is raised by four screws connected to structural iron links supporting the bridge. One nut engages with each screw, the four nuts being turned by worm gears connected to a shaft. Two screws and nuts are threaded right hand and two are threaded left hand, the end thrust on the shaft bearings being neutralized by thus pairing the thrusts; a gear on this shaft and a pinion on the motor shaft gives a speed reduction of approximately four to one.

The apron is raised by steel strand cables wound on grooved drums, the other ends of the cables being connected direct to the apron. Four gear reductions between motor and drums give a speed reduction of approximately 1 to 256.

Motors and mechanical equipment are mounted on the framework above the bridge, ample platforms giving ready access to all working parts.

The operator's cabin is on the track level, where the operator has a clear view of the respective levels of the tracks on the ferry-boat and bridge. Mechanical brakes operated by hand levers permit of stopping the motors at the proper points. Counter-weights are supplied, so that the greater part of the work done by the motors is in overcoming the inertia of the moving parts.

Hand wheels are retained for securing the boats to the bridge. There is some question whether motors can be applied to drawing in and securing the boats, though several methods have been suggested for this work.

One method would be to depend on overload circuit breakers. By setting the overload trip on the circuit breakers at a predetermined point, the motors could be operated until the tension on the hawser corresponds to the

OPERATOR'S CABIN.

tripping current, when the breakers would open and the drum would be locked at this point by the cog.

After the levels are adjusted the bridge and boat are locked by heavy bolts shoved into place and secured there by pins. The tracks are perfectly aligned horizontally by means of hand-jacks supplied on the bridge. The complete operation of making ready for the transfer of cars requires but a few minutes, though every precaution is taken to insure this transfer without the possibility of throwing the cars from the track.

Current for operation is taken from the regular three-wire 110-220 volt supply of the New York Edison Company, the power being connected to the outside wires and a small amount of current for lighting at 110 volt being balanced on each side of the system. One enclosed arc lamp serves to light the main entrance, and numerous incandescents are distributed as required. All lighting is weatherproof; porcelain sockets and a high grade of rubber covered wire are installed throughout.

The following data has been obtained:

	35 h. p.		7½ h. p.	
	Raise	Lower	Raise	Lower
Volts at main switch	240	240	240	240
Volts at main switch while operating	186	210	230	234
Volts at motor while operating	182	205	222	227
Volts drop in service	54	30	10	6
Per cent	22.5	12.5	4.2	2.5
Volts drop main switch to motor	4	5	8	7
Per cent	2.1	2.4	3.5	3.0
Amperes instantaneous	200	140	50	45
Amperes continuous	101	82	32	24

The excessive drop in the service is due to an extended length of wiring in the freight yard.

The following data has been estimated:

The total weight of bridge is estimated at 320.000 lbs. A portion of this weight is supported by the joint at the land end; the screws support the remaining portion of this weight, which is estimated as one-half the total plus 20.000 lbs., or 180.000 lbs., and in addition they support the weight of the end of the apron, or 28.000 lbs., giving 208.000 lbs. as the total weight on the screws. Two counter-weights are estimated as having a combined weight of 153.000 lbs., leaving an unbalanced weight on the screws of 55.000 lbs.

The bridge is lifted a distance of approximately 6 feet in one minute and forty-five seconds, then the actual work done is

$$55.000 \text{ lbs.} \times 6 \text{ ft.} = 330.000 \text{ ft. lbs.}$$

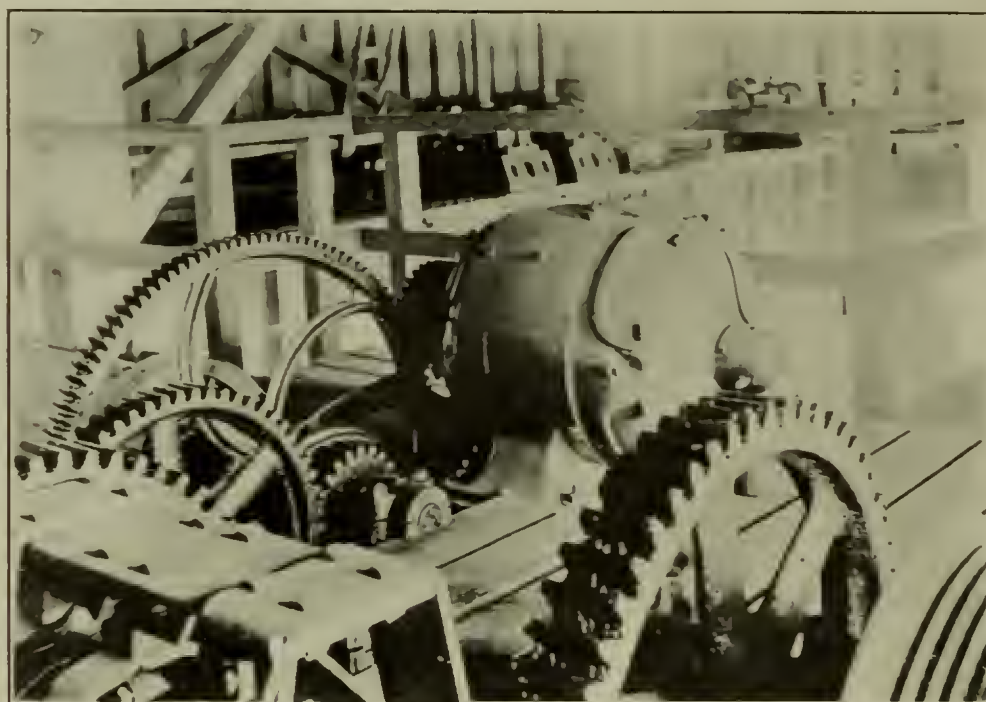
and since this work is done in one minute and forty-five seconds, the power is

$$\frac{330.000}{1\frac{3}{4}} = 190.000 \text{ ft. lbs. per min.}$$

or

$$\frac{190.000}{33.000} = 5.7 \text{ h.p. approx.}$$

The actual work done is therefore only about 5.7 horse-power, the remaining portion of the motor power is consumed by the gear friction. The efficiency of the gearing as estimated is good for installations having such a large reduction in speed, especially as the gears were new when this installation was tested and had not worn to their proper bearing surfaces.



APRON LIFT MOTOR.

The results secured from the electric operation of transfer bridges for freight have been so satisfactory that the railroads are rapidly extending electric operation to replace manual labor in raising and lowering the platforms for passenger ferries. This work is a large field presenting opportunities to the motor manufacturer not to be overlooked.

The Choice of Zero Reading and Direct Reading Testing Meters

PAUL MacGAHAN

THERE has been considerable discussion among users and manufacturers of portable instruments concerning the relative merits of the dynamometer or zero-reading type of construction and the direct swing type. It is the purpose of this

FIG. 1.—PRECISION WATTMETER.

article to show that the broad criticisms occasionally heard, directed against either the one type or the other, are not always justified and that the user should not confine himself strictly to either, but should employ both types as the service considerations demand.

The dynamometer, or zero-reading types of instruments consist of a movement so designed as to be in a constant position with reference to the stationary magnetic circuit; the torque between the stationary and moving elements being balanced by twisting the controlling spring by hand or other external means, or varying the position of the weights by hand in gravity-controlled meters. A pointer and scale indicates the position of the control spring or the location of the counterweight is indicated on the scale when the moving element is at the zero or balanced position.

The most familiar example of this class of meter with gravity control is, of course, the Kelvin Balance. An example of this class with spring control is shown in Fig. 1, which illustrates a "primary" or precision standard wattmeter intended for use in checking the secondary and other standards found in central stations and laboratories.

Fig. 2 illustrates a voltmeter intended for use on alternating or direct-current circuits. A different application of the balance principle is shown in Fig. 3, which illustrates a graphic recording wattmeter for use on either alternating or direct-current circuits. In this meter the control spring is actuated by an electro-magnet control system rather than by hand, and this control system in turn is governed by the balance element making suitable connections through a set of relay contacts. An example of the direct swing type of meter is shown in Fig. 4.

Practically all switchboard and portable indicating and recording instruments not included in the zero reading class are of the direct swing type, consisting of a movable element swinging in a magnetic field, the indicating pointer being attached directly to the moving element and opposed in its motion by a controlling element, such as a spring or a counterbalance.

The relative advantages of these two types of construction depend entirely upon the service required of

FIG. 2.—VOLTMETER.

them. Some instruments are to be used in a laboratory or testing room, where speed or convenience of manipulation is subservient to high accuracy. On circuits having great fluctuations or where the quantity to be measured is not readily controlled or where accuracy is not as important as convenience, the con-

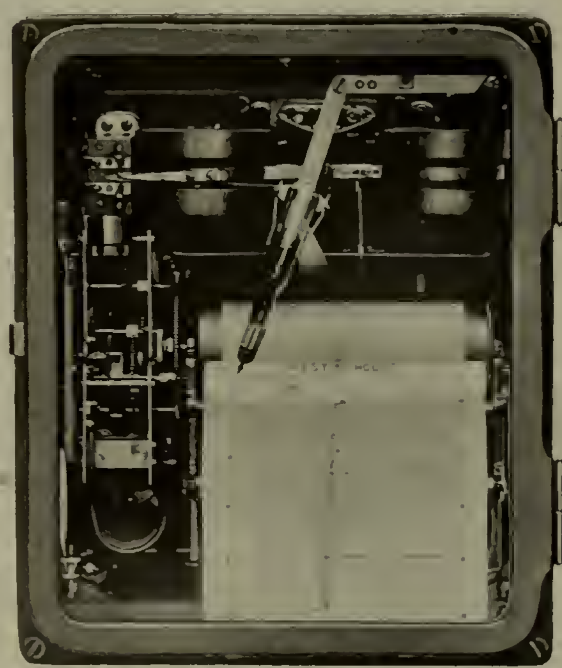


FIG. 3.—GRAPHIC RECORDING WATTMETER.

ditions are quite different. Under such conditions the average accuracy would probably be higher, when using a meter of inherently less accuracy, but of greater convenience. As a comparison it may be remembered that one cannot obtain satisfactory results with a high-powered telescope used at short range, such as in a theater or at a race-track. A lower powered, less accurate opera-glass would be superior for this purpose, as much so as it would be inferior for work where there is a steady support and slowly varying range of vision. It is always a case of properly choosing the tool for the work.

Many forms of direct swing instruments are at a disadvantage compared to the zero-reading types, owing to their inherently lower initial and life accuracy, lower torque, more fallible construction, susceptibility to error (on alternating current) due to variations in frequency, wave form, effect of external magnetic fields, inability to maintain as high an initial accuracy under severe operating conditions, overloads and shocks, possibility of damage to pointer or coils through swinging, and very short scale.

The characteristically weaker features of many "direct swing" meters are due to the construction necessary to obtain the direct swing feature, namely, in order to secure a large angular movement of the indicating element it is necessary to work the movements through a wide angle in the stationery field. This angular movement brings the moving system into a much weaker, more widely distributed magnetic field than that found in the zero-reading construction. The self-induction of any stationary coils must necessarily be greater than in the zero type; hence, greater frequency errors. There is a greater stray or useless field; therefore, more energy is required to operate the meter and the greater is the effect of external fields. It will therefore be seen that the balanced coil construction is inherently superior electrically and mechanically superior owing to the fact that the moving element travel is restricted to a few degrees and damage to pointer or movement due to overload, or jewel wear due to swinging, is eliminated.

The zero-reading type of meter is especially applicable in making tests when the voltage or load must be maintained at a constant value. In this class of service the the pointer controlled by the torsional head is set at the desired point on the scale and the operator has then only to manipulate the controlling devices until the pointer attached to the moving system indicates zero. This is a particularly valuable feature in testing arc lamps, transformers, meters, incandescent lamps, insulation, etc.

FIG. 4.—DIRECT-SWING TYPE OF METER.

On the other hand the zero-reading type cannot be advantageously used where the load varies quickly; where readings are to be taken at a distance, or in places subject to excessive vibration, such as on cars. For this class of work the direct-reading type is preferable, and by exercising proper care in handling, the results under such conditions would average up to a greater degree of accuracy than if the zero type were used.

The Dean Rapid Telegraph System

THE Dean Rapid Telegraph System is unlike all other automatic systems, and the basic principle is radical. The message is not transmitted from a perforated tape nor received on a tape, but is prepared in page form with an ordinary typewriter, using special type with dots and dashes above and below each letter. The dots are so arranged that positive and negative impulses are sent over the wire when desired. The alternating current is not used, but a three-wire motor generator is employed with the positive of one side and negative of the other side connected to the two styluses which alternates the current when needed.

The Hammond typewriter is employed in preparing letter telegrams. Instead of perforating the sheet, it is embossed and typewritten at the same time. If a mistake is made, it is not necessary to rewrite letter to correct error; the operator erases the embosses and rewrites the word in which the mistake has occurred. This enables the operator to prepare about fifty words per minute. After the letter is prepared for automatic transmission, it is fed through a transmitting instrument at a speed of from 300 to 500 words per minute, and received at receiving station in Gothic letters in page form. In the sending instrument two styluses are used to send positive and negative signals. The styluses are made of sapphire—ground to a certain angle suitable for the work which passes over the embosses and closes the metallic circuit.

While the emboss which the stylus passes over is small and delicate, yet it does its work perfectly, and the speed that is attained is marvelous.

The general construction of the receiving instrument is the same as the sending instrument, with the exception that it has a "printer" instead of a stylus. The "printer" consists of two characters, with which the entire alphabet is formed, or produced.

One character is actuated by the positive impulse, and the other character is actuated by the negative impulse. A polar relay of special design, having two armatures, is employed. One armature controls one character, and the other armature controls the other character, which is used in forming the letters. Since there are only two characters to produce the entire alphabet, it requires an alternation, and in some cases two alternations to form a letter. As it only requires one or two alternations to produce a letter, from 300 to 500 words per minute can be attained under the most unfavorable conditions.

The Dean Telegraph is perfected and has been tested, and is now doing commercial work between Kansas City and St. Louis on a phantom circuit, a distance of 320 miles. The system was operated on a phantom circuit between Kansas City and Joplin, Mo., for one month, and the splendid work done was beyond the most sanguine expectation. Hundreds of letters and telegrams are being handled daily for representative business men of Kansas City and St. Louis, and the numerous indorsements Mr. Dean is receiving daily speaks most flatteringly for the splendid work his system is doing.

Since the electric motor has become a fixture in the Southern cotton mills, that industry has reached a state of prosperity never known before, and since the electric power motor has been brought into the metal mining industry, many of the copper, gold and silver mines in Mexico, Arizona, Colorado, California and other Western mining regions have again begun operation after they had been abandoned, because power to run them was too expensive to obtain.

Electric Locomotives of the Pennsylvania Railroad

WITH a view to determining the type best adapted to pulling its heavy passenger trains through the New York tunnels, the Pennsylvania Railroad has in progress a series of experiments upon electric locomotives.

PENNSYLVANIA LOCOMOTIVE.

Through the experiments which are being conducted on its West Jersey and Seashore Division and the Long Island Railroad, the company intends to determine some of the general characteristics of the electric locomotive and to secure operating data based on actual service.

Of the two direct-current locomotives now undergoing tests, one is equipped with four 350 horse-power geared motors, and the other with four gearless motors in order that the relative merits of the two types may be determined.

The locomotive with gearless motors has one of its trucks equipped with two 320 horse-power motors supported by springs from the main journals and wholly independent of the truck frame, while the other truck has two 300 horse-power motors rigidly

THREE-QUARTERS VIEW.

fastened to the truck frame. This arrangement will demonstrate the advantages of the two methods of motor suspension under the same conditions of service.

In exterior appearance the two locomotives are almost identical. They resemble somewhat a short two-truck passenger car with few windows and large wheels.

The trucks are of the four-wheel type, having frames placed outside the wheels, with pedestal boxes and adjustable wedges similar to those used in locomotive practice.

On account of their short-wheel base, the trucks have a tendency to tilt in operation, and thereby shift a portion of the effective load from one pair of wheels to the other. By an ingenious automatic switching mechanism the power delivered by the motor on the heavily loaded axle is increased and the power delivered by the motor on the lightly loaded axle diminished, in proportion to the difference in axle loads. By this expedient the pulling of the heavily loaded axle is increased and the power delivered on the motor on the lightly loaded axle diminished, in proportion to the difference in axle loads. By this expedient the pulling power of the locomotive is increased 25 per cent.

The outer-end casting of each truck carries the coupler, draft spring and buffer arrangement, so that strains caused by pushing, pulling and buffing are taken directly by the truck frames and do not come upon the underframe of the cab, except as they are transmitted between bolsters through the center sill. In order to allow sufficient lateral play when the locomotive is coupled to a long passenger car with considerable overhang, the coupler head has a free movement of 15 inches on either side of the center line of the truck. To facilitate coupling and uncoupling on curves, the coupler can be swung sidewise and its uncoupling pin raised by means of levers at the end of the cab, which can be operated from the platform.

Driving wheels are 56 inches in diameter, with removable tires secured by retaining rings. They are carried by axles 8 inches in diameter at the center, provided with 6 x 11-inch journals.

The spring rigging is of the locomotive type, with semi-elliptical springs over the journal boxes, and equalizers between the springs. To prevent teetering, the equalizer beam is not provided with a fixed fulcrum, but instead supports two nests of helical springs, which in turn help to support the truck frame.

The collector shoes are attached to the four end journal boxes, and are made of two castings forming a spring hinge, with one wing lying in a horizontal plane, and sliding on top of the third rail. The current passes from the third-rail through the collector shoes and the heavy cables connected thereto, to the fuse-boxes located near the shoes.

The cab is entirely of metal, its underframe is composed of a center sill, built of two 10-inch channels, side sills of 7 x 3½-inch angles, plate bolsters and end sills. Within the cab the apparatus is distributed along the

END VIEW.

sides, leaving a passageway through the middle. The equipment on one side of the cab consists of three main reservoirs, a sand-box, with electro-pneumatic valves underneath, a switch group, two line switches, a case of diverters, and two sets of storage batteries. That on the other side consists of an air compressor, a compressed-air cooler, a fan and motor, a

INTERIOR.

reservoir for control apparatus, a sand-box, two line switches, a whistle reservoir, a motor cut-out, a switch group, and a case of diverters.

The locomotive control mechanism is in duplicate, and placed in diagonally opposite corners of the cab, so that the motorman can operate a locomotive, or group of locomotives, from either end of the cab, in either direction. By means of a special grouping of switches it is possible to obtain a constant flow of current without a break, when changing from series to series parallel, and from series parallel to full-multiple. The preliminary tests made with the locomotive proved that by means of this system of grouping switches, the acceleration of the locomotive could be made practically uniform. Both ends of the cab are provided with sockets, so that when two or more locomotives are coupled together connections can be made by means of these sockets, and the group of locomotives can be simultaneously operated and controlled by one motorman from one locomotive.

Hung from the ceiling in the center of the cab are two plug switches and an ammeter shunt. The conductors from the third-rail shoes are connected to one switch, and the trolley cable is connected to the other.

The switches in the switch group are operated by air pressure. The air valve is actuated by a control magnet on a fourteen-volt circuit. When current flows through the magnet the armature opens the valve controlling the air supply.

The cab can be lighted by three lamps. which are in a series with the lamps with the headlights; but normally these lamps are to be concealed. Five more lamps, which are in series, are distributed over the ceiling, to assist in lighting the cab when repairs are under way, but are not used when the locomotive is in service.

The storage batteries are in two sets, so that they can be charged alternately by being placed in series with the motor of the air-compressor, one set being charged while the other set is in service, the alternation being made each day.

Locomotives are equipped with hand, straight air, automatic and high-speed brakes.

PRINCIPAL DIMENSIONS—(SAME FOR BOTH LOCOMOTIVES).

Number of pairs of driving wheels	4
Diameter of driving wheels	56 in.
Axles, 8 in. diameter, 6 in. x 11 in. journals.	
Length inside couplers	37 ft. 10½ in.
Length over platforms	35 ft. 8 in.
Wheel base of trucks	8 ft. 6 in.
Total wheel base of locomotive	26 ft. 1 in.
Width, cab	10 ft. 1¾ in.
Width, body	9 ft. 11¾ in.
Height, rail to top platform	5 ft. 5 in.
Height rail to top roof	13 ft. 4 in.
Height, rail to top bell, extreme	14 ft. 5⅜ in.
Weight:	
Locomotive No. 1001 (with geared motors)	174,100 lbs.
Locomotive No. 1002 (with gearless motors)	195,000 lbs.

New Power Plant of the Patapsco Electric and Manufacturing Co.

THE Patapsco Electric and Manufacturing Company, Ilchester, Md., recently completed its new dam and power-house, which, as will be seen from the following description, furnished by the consulting engineers, Messrs. Newton & Painter, and given out by Allis-Chalmers Company of Milwaukee, whose generators are here installed, has many unique

DAM NEAR ELLICOTT CITY.

features. The power-house is placed inside of the dam, with the waste water passing over the top of it. The dam is situated on the Patapsco River, about 1½ miles below the company's other plant, or about three miles from Ellicott City and five miles from the western limits of Baltimore.

The part of the dam used as a power-house is 108 feet long, 14 feet high and 27 feet wide, except at the buttresses. where it is 18 feet. The power equipment consists of two 32-inch horizontal turbine water-wheels, running at 240 r. p. m., each direct-connected to 300 kw. 11,000-volt, 3-phase, 60-cycle Allis-Chalmers alternating current generators. It was decided to use 11,000-volt generators in place of stepping the voltage with static transformers.

The turbines are fitted with governors, so arranged that either will control both wheels when the generators are run in multiple. The generators have 125-volt belted exciters.

The switchboard located at the end of the power-house is 10 feet 8 inches long and 8 feet 3 inches high. stands 12 feet from the wall, and is enclosed by grillework on each end. It is fitted with three voltmeters, two of which are connected directly with two phases (at bus-bars) and the other through plugs, so that the other phase of either generator can be read. A synchroscope is placed under the voltmeters, all of which are mounted on swinging brackets attached to the end of the board. As the exciters are arranged to be operated in multiple, a regulator is used for controlling the voltage of the generators. Three ammeters have been provided for each generator, so that it can be told at a glance if either phase is overloaded.

Polyphase indicating wattmeters have been provided, one for the street service and the other to indicate the total output; also two polyphase recording wattmeters, one for street service and the other for the commercial and street feeders are fitted drawing wattmeter is further used for recording the total output of the plant. The leads to the generators and commercitl and street feeders are fitted with distant-control oil circuit-breakers with disconnecting switches. The breakers for generators have time relays, so in case of trouble on the outside feeders, they will not be thrown before the others.

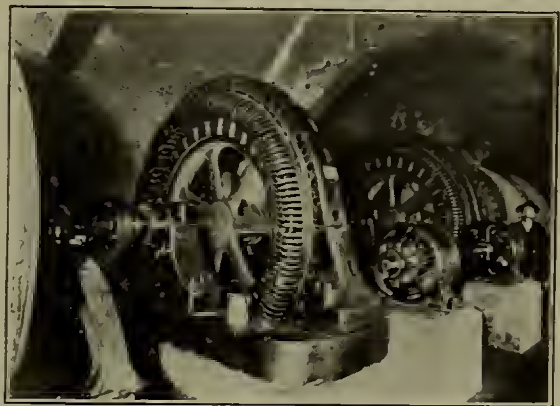
The dam has a length of 220 feet, and is 40 feet 9 inches wide at its base. Its height from the normal tail waters to the spillway is 26 feet 6 inches. At each end the buttresses and deck of the dam rise 10 feet above the spillway, so as to allow for floods. The spillway is 168 feet long and arranged with anchor bolts, so that in case it should be found desirable, planks can be bolted to it sufficient to add two feet. The dam is built of re-enforced concrete and the deck is supported by 19 buttresses 18 inches thick, which are spaced 12 feet centers. The deck of the dam is 18 inches thick at the bottom and tapers to 10 inches at the top.

The part of the dam used for housing the plant is fitted with a false ceiling hung 5 feet from the inside so as to protect the apparatus from any water that might seep through the deck. The ceiling slopes until it reaches the vertical sides forming the power-house. The side next to the tail-waters is fitted with windows. These windows furnish plenty of light, even when the water is flowing over the dam two feet deep. The part of the dam not protected by the false ceiling is comparatively dry, as very little water gathers on the inside of the deck, and what does collect there flows down the concrete deck until it reaches the drain at the bottom. If it were not for this moisture, it would not occur to a person that he was standing under water. The water for operating the turbines is taken through the deck 5 feet 6 inches below the crest of the spillway, which helps to keep the trash racks clear of driftwood, etc. Each trash rack is 10 feet 6 inches and the flumes to turbines 7 feet in diameter. Two waste gates are placed near the bottom of the dam, the water passing under the floor.

The waste water going over the dam is carried on the incline of the spillway to within 16 feet of the tail-water. This causes the water to fall about 10 feet from the side of the dam, and, as the river-bed is quite rocky at this point, the bottom is not pitted to any great extent.

The dam backs the water up three-quarters of a mile, with an average width of about 500 feet, to the tail-waters of a cotton mill located at Ilchester.

The plant will supply current for both power and lighting. At present Ellicott City, Catonsville, Irvington, Carroll, Halethrop, Arbutus, St. Denis, Elkridge, and a part of West Baltimore are being supplied from the other plant, the territory covered being about six by ten miles. There is quite a large day load, as about 250 h.p. in motors is supplied at different points. As soon as the new plant is in operation, it is intended to extend the lines to West Arlington and Mount Washington, about fourteen miles.



INTERIOR OF POWER PLANT.

Mr. Victor G. Bloede is president and general manager and Otto Wonder superintendent of the company.

New General Electric Instruments

A NEW line of ammeters and voltmeters for direct-current switchboard use has just been placed in production by the General Electric Company.

These instruments, which are to be known as Type D, are constructed on the D'Arsonval principle. A small coil of wire mounted on a light cylindrical aluminum frame is pivoted in jeweled bearings so as to move freely in a small annular space between a soft iron core and the pole pieces of a permanent magnet.

The operation of these instruments is rendered dead beat by the Foucault currents generated in the aluminum frame as it passes through the field of the permanent magnet. This damping quality prevents injury to the pointer from violent load fluctuations and permits rapid and accurate readings as the pointer comes quickly to rest after each change in current value.

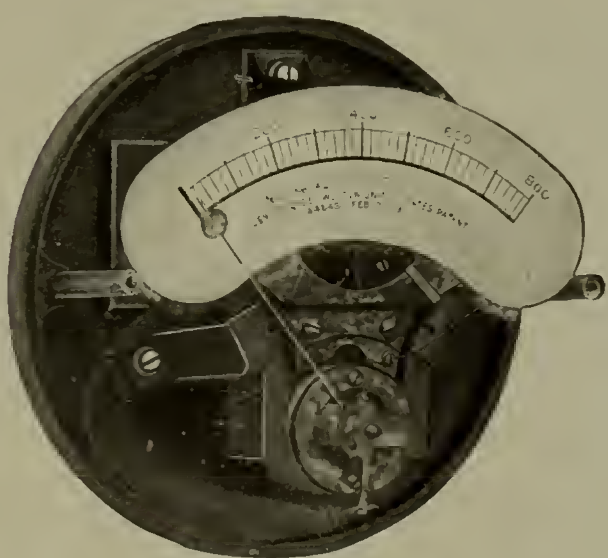
Continued accuracy of Type D instruments is assured by the unusually high torque, light-moving elements and the very small air gap between magnet-pole faces and the iron core combined with the permanency of the magnets which are made from the

TYPE D AMMETER.

best obtainable grade of magnet steel and subjected to special processes of hardening and aging which fixes its magnetic characteristics.

The round cast-iron case which encloses the instrument protects it from the effects of stray fields and makes it dust-proof.

Inspection or repairs of type D instruments is easily made. The soft iron core together with the armature and jewel supports are assembled



INTERIOR OF METER.

within the soft steel shell constituting the pole pieces. By removing the screws which hold the shell to the magnet-pole faces, the entire mechanism may be removed.

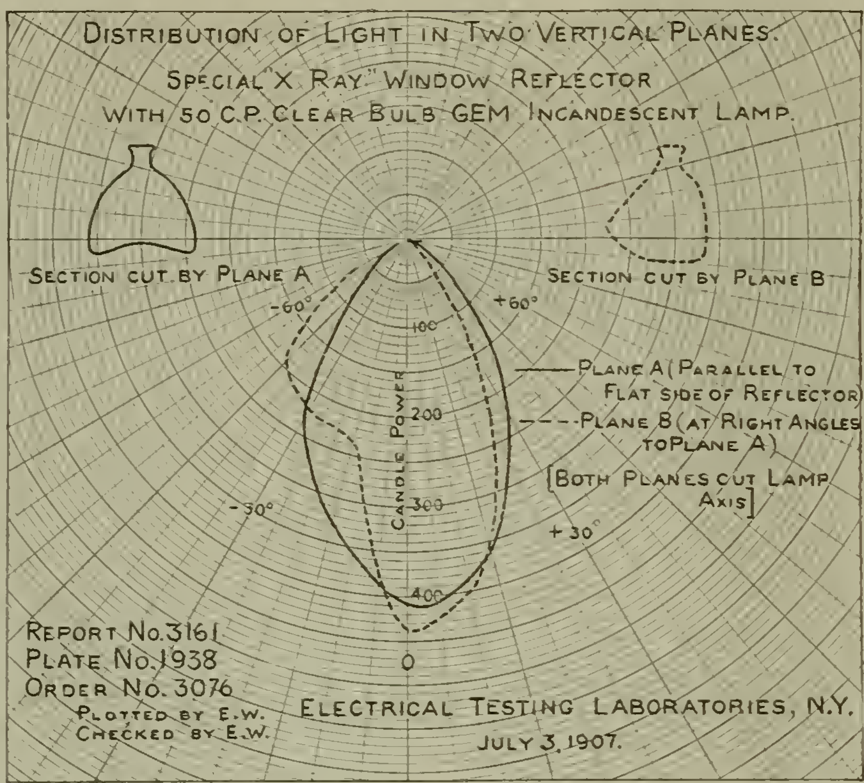
The scales of type D instruments are uniform throughout their entire range and very legible. The standard finish is dull black with raised portions polished copper, making a very pleasing and durable surface.

Type D voltmeters are made self-contained in capacities up to and including 750 volts. The ammeters are self-contained up to 60 amperes capacity. Larger capacities are furnished with external shunts, which are made of a special alloy having practically a zero temperature coefficient. All instrument shunts above 1000 ampere capacity are now provided with a thermo-electric attachment. This attachment consists of a metal strip having one end electrically connected with one end of the shunt, with the other end in close thermal contact with the other end of the shunt but insulated from it electrically. The ammeter leads are connected to the shunt and to the metal strip at the two insulated points. The thermo-electric attachment thus prevents the superimposing of secondary thermo-electric currents upon the current, which is due to the fall of potential in the shunt and the amount of which fixes the value of the indication of the instrument. Ammeter shunts with this attachment will be found free from temperature errors due to generation of thermo-electric current.

The New X-Ray Helmet Reflector

THIS reflector has been recently brought out by the National X-Ray Reflector Company, of 247 E. Jackson Boulevard, Chicago, Ill., which is designated the "Helmet" reflector. It is specially designed to meet the requirements of lighting high and shallow windows, many windows at the present time being of this class. It is suited to the lighting of all windows over 12 feet high where the depth of the window is less than one-half the height of the lamps above the bottom of the window, where the lamps are as high above the level of the top of the back of the window as the window is deep. This meets the conditions in a great many windows at the present time. It is intended to produce an approximately uniform illumination over the goods as ordinarily placed in show-windows. This reflector marks a most decided advance over anything heretofore offered for lighting this class of windows.

In the first place, it is designed to use a 125 watt Gem incandescent lamp, thus giving the user at once the advantage of a 25 per cent. increase in efficiency over the old style carbon filament lamp. It has the further advantage that it will also take a 105 watt Tungsten lamp; so that the user can install these lamps as soon as they are placed on the market. Future improvements in incandescent lamps have therefore been anticipated. This reflector has one side partially flattened and extended down lower than the rest of the reflector. This flat side is placed next to and parallel with the window-pane, and is designed to avoid as far as possible the wasting of light on the sidewalk and detracting from the value of the window illumination by exposing the lamp to passers-by. The reflector is unusually large, being about 12½ inches in diameter and 11½ inches high. This size was necessary to secure high efficiency of window illumination by



RESULTS OF TEST.

catching as much of the light as possible and reflecting it in useful directions. Another important reason for the peculiar shape of the reflector was to make it easy to install without mistakes. The makers realized in adopting this design that many excellent reflectors of conical form are commonly misused in window lighting, because the average person who installs and uses these reflectors does not understand the importance of pointing them at the proper angle. This new reflector was therefore so designed that it is practically impossible to improperly install it, and it is designed so that the lamps point straight down. It is only necessary to install a row of wall sockets pointing straight down along the top of the window and to place the reflectors on the sockets with their flat sides parallel with the window-pane, just as one would naturally do without instructions. Their efficient installation is therefore very simple. Furthermore, by having the lamps pendant, use can be made of the new Tungsten lamp, which would not be the case if the lamps were at an angle. The efficiency of this reflector for window illumination for the size of windows for which it is intended is remarkably high, as can be seen from photometric curves plotted from tests made by the Electrical Testing Laboratories of New York. In these tests the reflector was equipped with a 125-watt clear bulb Gem lamp, giving 50 mean horizontal candle-power. The reflector was held in a position as used in practice with a standard 3¼-inch holder. The lamp was placed in such a position that the plane parallel to the loops of the filament made an angle of 45 degrees with the flat side of the reflector. Tests show that over 200 candle-power is given for a distance of 40 degrees to the left of vertical in the direction in which it is most useful in window lighting, while for a few degrees the candle-power is 436. The maximum candle-power is directed so as to give high illumination on the goods placed in the bottom and front of the window. As higher goods are usually placed farther back in the window, a lower intensity is needed, and these requirements are met by the reflector. A very small amount of light is thrown outside the window on the sidewalk.

With a reflector of such weight, it is well to have it in good mechanical balance to avoid the twisting of shade holders and sockets. The weight is distributed in this reflector so as to secure such a balance.

Besides window lighting a number of other useful applications of this reflector will suggest themselves to illuminating engineers—most notably the lighting of audience rooms of all kinds where the lamps themselves are concealed behind ground-glass skylights or beams, and where it is desired to throw the light sidewise and forward and have as few rays directed back into the eyes of the audience as possible.

For the lighting of high, shallow windows, the makers are putting out this reflector with the claim, based on these photometric curves, that one 125-watt Gem lamp with this reflector will give the same results as three 55-watt common incandescent lamps used in the most efficient window reflectors for high, deep windows that have been offered up to the time this reflector was designed, while in the many cases where mirror troughs or other reflectors unsuited to such windows have been heretofore used, one 125-watt Gem lamp will give the same results as four or five common 16-candle power, 55-watt lamps. With Tungsten lamps, having twice the efficiency of Gem lamps, the saving would be even more marked. The makers claim the honor of being the first to put out a window reflector designed for the new, large, high-efficiency, incandescent lamps.

New Warehouse at Newark

THE opening of the immense building at Mechanic, Lawrence and Ward Streets, Newark, which the Newark Warehouse Company has constructed for the better handling of freight coming into that city on the New Jersey Central has been announced.

Railroad men say that the warehouse is unique, and that there are few buildings in the country better adapted for the purpose for which it has been built. The cars of the New Jersey Central will be switched into the ground floor of the structure, where their contents will be unloaded and lifted by means of a complete elevator system to various floors set aside for the different classes of merchandise, there to be stored until the consignee wants them, or else unloaded directly onto trucks.

The entire building is of re-enforced concrete. There is nothing in its construction that can burn. If the merchandise stored there should, by any means, catch fire, there is in addition a complete sprinkler system so that the risk from flames is reduced to a minimum.

An idea of the size of the structure, which occupies a city block and is six stories high, may be gained from the fact that there is 370,000 square feet of floor space. The total weight of steel used in construction is 6000 tons. There are fourteen elevators and eight gravity conveyances. Fifty freight cars can be accommodated on the tracks inside the building and there is room for the storage of 1200 carloads of freight.

Lusitania—Electric Equipment

THE electric equipment of the *Lusitania* is of interest on account of this being one of the first large steamships equipped with turbines. Electric light and power is supplied by four Parsons-Brown steam turbines running at 1,200 r.p.m. and generating current at 115 volts. These machines are rated at 3,260 amperes. One of the first noticeable points is the construction of the commutator, which is grooved with grooves approximately ⅛ inch wide and ⅛ inch deep. Brushes are copper and consist of bunches of small copper wires of approximately No. 28 B. & S. gauge. The commutator contains bands of fan blades which assist in ventilating. The generators have neutralizing poles; they are four-pole compound wound. Operation is practically sparkless at full load.

An oiling system with forced circulation is used, the oil passing through coolers where it is cooled by water circulated around the jackets. Safety stops are provided by means of which the generator can be immediately stopped by hand or when a predetermined speed is exceeded.

There are four switchboard panels, or rather two switchboards consisting of two panels each. A fire-door separates the two pairs of generators and switchboard panels so that either will be operative in case of accident to the other. The switchboard bus-bars are connected by circuit breakers at the fire-door. There are four ammeters on each half of the switchboard so that the output of any machine can be read from either side of the fire-door. Instruments are of the Ferranti type.

There are two electric elevators operated between decks A and E. These elevators were supplied by the Waygood & Company, Ltd., of London, and each is operated by a 15 b. h. p., 110-volt, 600-r.p.m. motor.

A complete system of ventilation is provided. Ventilating fans supplied by the Thermotank Ventilating Company are installed at numerous points. Motors are entirely enclosed and controlled from a water-tight rheostat. The rheostat is operated by means of keys. Glass-covered openings permit of viewing the position of the contact arms.

Electric-lighting fixtures conform in general with the artistic paneling of the ceilings in the different saloons. These saloons have white ceilings which aid materially in distributing the light. The fixtures are either supplied with glass globes or are in the form of candles, each being operated by a snap switch with ball handle.

FIRST CLASS DINING SALOON.

Deck lighting is provided by incandescent lamps entirely enclosed in bull's-eyes with tight-fitting covers. Every precaution has been taken to render the wiring throughout absolutely water-tight and moisture proof, lead covered wire being used.

SELLING CURRENT

Registered 1907

Commercial Experience

C. N. JACKSON

DURING the summer of 1901 the Toledo Railways and Light Companies was purchased by the Everett Moore syndicate of Cleveland.

Mr. L. E. Beilstein was appointed general manager.

I was employed for the contract department.

It would be almost impossible to describe the unbusinesslike methods in use. There was no filing system. Letters from customers and all data on all matters were thrown in a confused mass in the drawers of several desks.

There were two so-called solicitors who did not seem to do much except quarrel with the customers. They charged the largest stores anywhere from 4c. to 8c. for light. The smaller stores paid from 8c. to 10c. and residences paid 12c. How the prices were made no one knew; they had always been that and the contract department had left well enough alone.

One very glaring example comes to mind. A large wholesale grocer that did considerable manufacturing owned its own plant, from which was furnished possibly 100 h. p. in motors and a few hundred lights. In the winter they would shut down the plant at about 5 o'clock, and throw the entire load on the Toledo Railways and Light Company for a few minutes each day. I believe I am safe in saying that we carried at times 40 or 50 kw. for a few minutes and all we received for this service was about $60 per year. Would that not surprise the up-to-date manager of the present day?

A great many customers used gas and electricity—electricity in the summer and gas in the winter—except during the holidays, when they would turn on both and probably increase their electric load. Their demand on the power station peak was just as great as though they used electricity exclusively all the time. The December peak on the three-wire direct-current system which supplied the business district was 1800 kw. in the year 1900; in 1901 it was 2300 kw., an increase of 500 kw. in load and the gross earnings on that system were only increased $22,000 from January 1, 1900, to January 1, 1901.

After Mr. Beilstein took charge Mr. E. J. Bechtel, superintendent of lighting and electrical engineer, was then in a position to put the business in a good, healthy condition.

We immediately began to study the question of cost, and soon ascertained that it cost, counting interest, depreciation, etc., about $50 per year per kw. demanded and about ¾c. per kw. hr. to serve our customers. In other words, if all of our customers would stop using the service for a short period, a month or two, our fixed cost would be just the same. There would be no station output which would save us ¾c. per kw. hr., which was running cost. Or if we should connect a new customer who would not use the service at time of peak load our service would only be increased ¾c. per kw. hr. used, barring the small amount to cover cost of meter maintenance. I will not go into details on how we arrived at the above basis or how we classified our account, as it is a long story, which I will cover at another time.

After finding out what it cost to serve a customer on or off the peak, the most momentous question was, "How to charge?" First we tried charging according to connected load. Estimating the connected load to be about double the power-station peak, our fixed cost was about $25 per kw. connected. This was fine *for the customer* when he had about 100 per cent. load factor. But we could not obtain business where the maximum demand was below 25 per cent. of the connected load, so we soon saw that if we continued on that basis we would have a great many unprofitable customers; like a certain Canadian manager who *gave* his customers their choice between a ready-to-serve rate and a straight meter rate. Naturally all of the long users took the ready-to-serve rate and deprived the electric company of any extra profit it might have received at meter rates. As the unprofitable short-hour customers selected the straight meter rate the electric company lost with both rates.

You cannot carry 50 per cent. of your customers at cost plus a reasonable profit and the balance at less than cost and make money.

For example, a certain saloon paying 8c. per kw. hr. used its entire connected load of one kw. on an average of seven hours per day, or about 2100 hours per year, for which they paid at 8c. $168. Calculating on a basis of $25 per year per kw. connected and 1c. per kw. hr., the saloon would only pay a ready-to-serve charge of $25 plus $21 for 2100 kw. hrs. at 1c., or $46, which would cut the revenue from $168 to $46, amounting to a loss of $122. He would profit by the ready-to-serve rate. Then if we give a short-hour burner, who uses only about 25 per cent. of his connected load only 300 hrs. per year, his choice of rates, he will of course accept the 10c. straight meter rate, as his bills would only be $7.50 per kw. connected per year. We finally decided to charge $60 per year per kw. *demanded*, and 1c. per kw. hr.

We then began to check up all customers and ascertain if their annual bills would amount to $60 per kw. demanded and 1c. per kw. hr. Whenever we found one that was considered unprofitable we "boosted" him to an amount high enough to make him a profitable customer. Where electric light was used exclusively we did not have much trouble doing this except with large wholesale houses, who, on account of their size, received probably a 7c. rate on the old method; this class of business should have been written at from 10c. to 12c. In such cases we would keep after them, and in time get them on a profitable basis, or lose them entirely, which did not happen often, as we argued the fairness of our system and referred them to customers who had received a big reduction in their rate because of longer use per day.

We did cut many rates, but always with a view to increasing *net* earnings. For example, a certain large department store had an 8c. rate. They used electric light only in windows and places where it was a convenience, while during the holidays they would turn on everything, probably 30 kw. Our revenue from this store was only about $1,000 per year. When their rate was cut to 4c. they quit using gas and consequently used about five times as much current as formerly, which at 4c. would amount to $2,500 per year. The demand being 30 kw. the ready-to-serve rate at $60 per kw. demanded per year would be $1,800, adding to that 62,500 kw. hrs. at 1c. would make the total that we should receive $2,425. Thus in this case by cutting the 8c. rate in half we increased our revenue $1,500 per year, and only increased our expenses about $375, which is about what the extra current would cost after all fixed charges were paid.

On the old basis this store *cost* us $50 per kilowatt per year, or $1,500 plus 12,500 kw. hrs. at ¾c.=$93.75, or a total of $1,593.75; consequently we were losing $593.75. On the new contract it cost $1,500 plus 62,500 kw. hrs. at ¾c.=$1,968.75, which gave us a *profit* of $531.25.

Such contracts as this were good talking points, as we could refer to them to show the fairness of our system. We gave the people to understand that the law allowed us to charge them as high as 12c. per kw. hr., with a monthly minimum of 10c. per 16-candle-power lamp or equivalent. By admitting that such a law was in force everyone accepted it.

When we could not raise the unprofitable customer's rate we lost no time in getting rid of him, and in many cases we would serve notice that we would remove service on a certain day if he did not sign the contract calling for the higher rate. We were just as glad to get rid of him as we were to get a new profitable customer, as the results at the end of the first year showed that we increased our earnings $33,000 and only increased the power station peak 100 kw. The following table shows the results of the new system of charging:

Year	December peak in Kw.	Increased load Kw.	Increased earning
1900	1800	....	......
1901	2300	500	$22,000
1902	2400	100	33,000
1903	2500	100	35,000
1904	2625	125	40,000

You will notice that under the old system, from December, 1900, to December, 1901, there was an extra load on the power station of 500 kw. to carry business that only increased the earnings $22,000. If the old policy had been continued an increase of $108,000, which was the increase from 1902 to 1904, would have required the installation of 2,450 kw. additional in the power station. As a consequence of our policy it was not necessary to invest a dollar in new machinery; a 400 kw. rotary was installed temporarily to carry the peak in 1902, but was not used; nearly all of the increased revenue went into *net* earnings. As the same labor and machinery handled the load, only the coal expense was increased.

(*To be continued*)

Co-operative Commercialism in the Electrical Field

J. ROBERT CROUSE

INTRODUCTORY.

THROUGH the continued courtesy of your officers, yourselves and your special committees, it has been my pleasure on a previous occasion to raise the question of closer commercial co-operation at Cleveland, Ohio, in 1906.

The conditions which suggested the idea, the organization which nurtured it, the trade relations existing, and the essential points pertaining to its earlier development, are of record in your previous proceedings and will, therefore, not be again reviewed.

The force of the idea, the practical nature of the plans, and the efficient results obtained are such, I confidently believe, as will increasingly commend the subject to your best sentiments and business judgment alike.

The entire proposition, may I ask you at the start to view as the product of the co-operation of many men who have been willing to venture their time and considerable sums of money in bringing to a practical working basis. The degree of its future success likewise will depend upon the extent to which it can effectively appeal to all the branches of the trade for both their moral and financial co-operation.

OBJECTS.

The objects of this co-operative movement briefly stated are as follows:

1st. The promotion of the increased and more extended use of electric current by the public for light, heat and power against all competitors for like service as an end in itself and as a means to the increased demand for electrical apparatus and supplies and the co-operative planning and execution of various means and methods effective to this end.

2d. The establishment of co-operative commercial relations, both moral and financial, among the different electrical interest from the manufacturer to the consumer to the end that each may contribute in some measure toward bringing about the above results desired in common by all.

DOUBLE ASPECT.

The subject presents itself at once in two aspects:

First, as a theoretical principle in business development.

Second, as a practical workable refinement in business organization.

Read before the National Electrical Contractors' Association.

THEORETICAL ASPECT.

Commercial co-operation, which we are all dealing with daily, consciously or unconsciously, in the development and management of individual business, is a thoroughly accepted principle and a recognized factor in increasing productive and distributing efficiency.

It amounts to the recognition by increasing numbers of men, of the fact that they can gain more individually by joining others in the prosecution of an enterprise, than is possible in an equal degree by their segregated, conflicting, individual effort.

Within the memory of men present, business has passed consecutively through the periods of individualism, co-partnership, corporation, consolidation and association.

This rapid transformation in method has been based upon, and in proportion to the recognition of broader grounds of common interest, on the basis of which, notwithstanding necessary differences, more effective means for their prosecution has been undertaken.

Each advance has been in effect a refinement of the co-operative principle, and has justified itself fully through tremendous increase in the efficiency of production with more questionable gains in the field of distribution.

Summed up in a paragraph this development has amounted in some directions to the reasonable restraint of such competitive effort as tends to defeat the real objects of more efficient production and distribution and in other directions to the stimulation of competitive efforts in channels where the result is a gain to those ends.

It is to be observed that the field of manufacture or production has offered the widest play for enormous gains in the efficiency of production through specialization, co-ordination and co-operation.

Selling and distribution, on the other hand, have not made any comparable gains in efficiency, although refinement and complexity of organization have been steadily progressing.

All this massing and complexity in the distributing field has incited competitive neutralizing resistance so that progress as a whole has been made, at a maximum expenditure of money and effort.

Production has been subject to the advantageous working of the economic law of increasing returns, while distribution has been rather subject to the limitations of the economic law of diminishing returns.

If, therefore, within a given business, such as the electrical business, a plan of co-operative commercialism can be found which will develop under the economic law of increasing returns and escape from the wastefulness of unrestricted competitive distribution which is subject to the economic law of diminishing returns—such a plan, I believe, must commend itself to your careful consideration.

Even this hasty review of the development of commercial co-operation leads inevitably to the conclusion that, as at each step its application has increased real efficiency, so its further extension along lines dictated by its past evolution must carry corresponding gains.

So much for what one may choose to call the academic side of this proposition, which will be disposed of with the practical statement with which we will all agree—that a theoretical proposition is practical when it works.

PRACTICAL ASPECT.

The practical consideration of this question involves three propositions:

In the first place, as to whether we have not now reached a stage of business development where a community of commercial interests actually exists of which we are not taking full advantage. Whether by further extension and adaptation of commercial co-operation among ourselves we cannot more effectively and extensively influence the public to a larger and larger proportionate expenditure for electrical service of the eighteen billion dollars of wealth annually produced, rather than that it should be stored in savings banks, expended on automobiles, pianos, talking machines, etc., to say nothing of the appliances and devices which immediately compete with cheaper and inferior service for light, heat and power.

Second, if the existence of such a community of commercial interest can be so established, the second proposition involves the question as to whether practical plans can be presented to reap the advantages.

Third, assuming the first two propositions, the third point involves the question as to whether per unit of money and effort expended on the plans they will yield a better return than it is now possible to secure.

As to the first proposition, we have passed in the electrical field through all the various stages of commercial development and have reached the period of associations, which exists in one form or another; City, State and National in the central station, contracting, jobbing and manufacturing fields.

An analysis of this broadening interest in co-operative or associated work is seen to rest upon an interdependence of commercial interests peculiarly strong.

First, this is noted as among the different services furnished for lighting, heating and power. The introduction of one service strongly disposes the users, as well as others, to the employment of the other two. The development of the lighting service immediately emphasizes the necessity for the development of the power and heating service, and upon the proper balance of the three largely hinges the future development of them all.

This community of interest seems clear when one considers that the electrical devices in which the public either are or can be interested are comparatively few in number for lighting, heating and power and relatively small in money value, yet upon their increased sale and use depends, first, the success of the central station and the contractors, and second, that of the jobber and the manufacturer.

The market for us all, therefore, whether reached directly or through and against one another, is in the end this great money-spending public, pre-occupied, incredulous and indifferent to the advantages of electrical service, so apparent to ourselves.

This question, then, of popularizing and educating the public to the freest possible use of electricity, for light, heat and power is a vital, existing community of interests to us all, whether we manufacture, job, construct, or sell current.

We are, in fact, joint sellers of the final service. Here is the edge of the commercial wedge which we owe it to ourselves and to one another for the purest of commercial reasons to drive home by the most effective methods for the expansion of the market, common in this degree to us all.

As to the second proposition, involving the question of practical plans, the following are the plans already formulated, which have been reviewed and favorably passed upon by your special committee of two years' standing as well as committees of all the representative associations in the electrical field. Some of them have been put into operation, but many of them remain for the future, and are contingent upon widespread moral and financial co-operation toward which we are aiming.

GENERAL CHARACTER OF PLANS.

Broadly speaking, the plans as formulated aim at the creation and extension of the market along three lines.

1st. Through creating the favorable conditions and providing the proper facilities for the most rapid and flexible interchange of the best commercial ideas and methods throughout the non-competing branches of the trade, the contractors and the central stations in particular.

2d. By bringing to the effective support of the non-competing branches of the trade the further united commercial stimulus and backing of the competing branches, the manufacturers and the jobbers.

3d. The massing of the combined selling strength of all branches on the common market, the public through a national campaign of advertising and commercial publicity, exploiting the generic uses and advantages of electrical service, and by reaching in addition allied lines such as architects, builders, contractors, real estate dealers, etc., with subsidiary campaigns and personal work.

The successful execution of the detailed plans will increasingly generate the disposition on the part of every one concerned to lend a hand, and this in turn would insure the further extension and prosecution of the movement to which at the present time there appears to be no visible limit.

In discussing the detailed plans of this Association in those respects in which I believe they have a proper bearing on the contractor's business, I will follow the subjects treated by your very able and worthy President before the National Electric Light Association last month in Washington. They are, in order:

1. The wiring of buildings, to which I will add new business getting in general.

2. The standardization of work, materials and appliances.

3. Trade relations.

As to the present status and commercial attitude of contractors in general, I quote the following direct from your President's address, which I may say is further supported by articles appearing in your trade journal during the past year:

"His daily effort (referring to the contractor) is in the line of increasing his business, but I believe that in most cases this effort is misdirected and wasted. I think that the contractor devotes less energy to obtaining new business than to the execution of the business in hand. Contractors as such are not advertisers. They rely almost entirely on personal effort for the extension of their business, and as his personal effort must also supervise the work in hand, it naturally follows that the solicitation of new business goes to the wall, and as a result the contractor's business continues without substantial increase from year to year."

(*To be continued*)

Review of Papers Read Before the Ohio Electric Light Association at Its Thirteenth Convention

Held at Toledo, Ohio, August 20, 21 and 22, 1907

FACTORY LIGHTING.

SEVERAL practical points were given by A. P. Biggs in his paper on factory lighting. He divides the lighting of factories into two classes, namely, space and applied lighting. For general space and floor lighting there must be some large source of artificial light, and the sources now available for this purpose are the electric and gas arcs, the Cooper Hewitt and Nernst lamps. An arc requires but small cost for installation, has a high efficiency and low maintenance cost. The Nernst lamp is desirable for small space lighting in low-ceiling machine shops and in foundries. The light is soft and pleasant and the current consumption is low. For particular application of artificial light, single incandescents are the sources used. Although the installation of a lamp at each machine is not sanctioned by all illuminating engineers, it has the sanction of custom.

In shops having low ceilings and much window surface illumination may be good from natural sources for the first six months or so, but after that the windows, ceilings, walls, posts, etc., blacken and cease to let in or to reflect light.

An example of shop practice with individual lights is given; a bare lamp, 13 inches above the face-plate of a drill-press and 7 inches from center, gave 3.7 foot candles at center of face-plate; the dirtiest lamp in the shop, when substituted, gave 1.55 foot candles, while a new clean lamp in the socket gave 5.7 foot candles. Eight-candle-power lamps are recommended.

The writer gives the policy of his company as advising the use of gas arcs for space lighting for short-hour burning. He says that all possible short-hour burning is turned over to the gas company. This policy results from their differential rates, the differential rates being high for short-hour burning, and consequently causing dissatisfaction to short-hour customers.

The usual factory lighting can be considered by central station men as unprofitable business, which is a necessary evil. The assumption is not to be made that his company is securing proper and adequate returns for its service in this branch of lighting; the company has certain rates and is, as a public service corporation; required to furnish, and does furnish service for all the customers. Further, it is needful that this unprofitable business have a fairly low rate in order to get the profitable business that goes with it.

The rates in Detroit are: First, open order—60 hours' use per month of the demand at 16 c. per unit, balance at 4c. per unit. Second, demand contract—30 hours' use per month at 16 c. per unit, balance at 4 c. per unit, minimum bill, 30 hours' use per month of maximum demand at 16 c., term one year. The following discounts for prompt payment are allowed on both agreements: On bills less than $50, 10 per cent.; on bills $50 and less than $100, 15 per cent.; on bills $100 or more, 20 per cent.

Under "open order" standard incandescent lamps and renewals are furnished and arcs and Nernst lamps owned by customers are trimmed and maintained. Under "demand," all incandescents, arcs and Nernst renewals and maintenance are furnished.

The "open order" is the most common for factory lighting. It cares for short-hour customers who use electric lights as auxiliary to sunlight and daylight. The "demand" contract is suited to the lighting conditions of but a small portion of factories, as it is designed for the satisfaction of long-hour burners.

To illustrate that factory lighting is unprofitable, the following cases have been figured to show cost to customer of the "open order" and "demand" contract, and the amount the business should have brought in in order that it might just begin to be profitable. The latter amount being arrived at by adding the fixed charge per kw. per year to the operating cost per kilowatt-year.

No.	Kw. hrs.	Connected Kw.	Demand Kw.	Earnings Open Order	Income per Year. Demand Contract	Income per Year. Minimum Allowable
1.	4330	29.0	12.0	$552.00	$632.00	$780.00
2.	8163	36.6	13.5	916.00	815.65	973.89
3.	1800	5.6	2.2	220.00	157.00	172.30
4.	6850	30.6	22.2	884.00	1061.70	1410.80
5.	10410	26.3	17.6	1168.70	875.80	1262.80
6.	3052	16.6	9.16	416.70	492.93	500.40
7.	1644	5.1	2.81	226.73	170.25	201.10

Nos. 1, 2, 3, 4 and 5 are on open order, No. 6 on demand contract and No. 7 on open order. The first three calculations are for a carriage manufacturer in successive stages of his business. For two years he did all his lighting by clusters; at the end of that time, by reconstructing the building and adopting gas arcs for all general floor lighting, the electric lighting was reduced from 13 kw. demand to 2 kw. demand. Only in the third year, after the changes had been made which deprived the electric company of serving 650 lamps, did the electric company make profit in the business.

The fourth and fifth calculations are for successive years in a cigar factory—a six-story building lighted throughout by incandescents. At the end of the first year the customer was persuaded to change 300 individual lights from 16 candle-power bare to 8 candle-power with reflectors. The demand was reset and he was billed upon 60 hours' use by its readings, as he was an open-order customer. He saved considerable, and the lighting company only lost 10 per cent. on the lighting business against 60 per cent. the year before. His power business in the last year amounted to 30,800 kilowatt-hours with a demand of 11.6 kw.

The sixth is a manufacturer of shirt-waists, skirts, etc.—an all-electric equipment, using electric arcs for general floor lighting. His lighting business was on demand contract, and caused a loss to the lighting company of about $8. During this year the lighting company had the profit from the sale of 20,000 kilowatt-hours for power with a demand for 8.5 kw.

The seventh, which is a bath-tub factory, has a floor-space of 20,000 square feet, with wood-working, sheet metal and brass foundry departments. For space lighting gas arcs were used, and the business gave some respectable return.

As a public service corporation having established rates, this company must sell at these rates whether a gain or a loss results from supplying the service.

Demand indicators are used to obtain the maximum demand for each customer.

A business is shown to begin to be profitable when the customer has paid for 480 hours' use of demand per year at 16 cents; say 40 hours per month. As an approximation to obtain a classification of business as profitable or unprofitable the consumption of current per year by factories as found in several customers' ledger accounts has been divided by twelve times the demand, giving the hours use of demand per month. All of these factories are operating on a regular ten-hour day.

Number of cases.	Average hours use of demand per month.
5 bakeries, wholesale	107
8 brass works	57
2 breweries	85
2 brush	12
4 candy	51
3 chemical	10
7 cigar	29
9 clothing	37 (5 cases average 11.9)
3 engravers	70
3 harness	35 (2 cases average 11.9)
1 knitting	9
14 machine shops	31 (7 cases average 13.4)
3 paper box	13
4 printing	20
8 sheet and metal	18
3 shoes	33 (2 cases average 13.7)
2 toys	31
1 upholstering	4
1 wire works	12
6 wood working	24 (4 cases average 11.1)

From their nature several kinds of business are invariably profitable. The wholesale bakers use some lighting for 24 hours per day. Brewers have considerable small power about their establishments, which are shut down about 4 P. M., and the lighting load up to that time continues quite uniform throughout. Machine shops and brass works need electric light for individual machines only and give a good lighting load summer and winter. The clothing manufacturer whose record makes the best showing of his class has on each machine a movable arm carrying a lamp of low candle-power with a parabolic reflector. All his space lighting is by gas arcs.

The lighting company persuaded one customer operating a brass foundry to put in gas arcs for all lighting.

The writer's conclusions are: that an electric-light company cannot afford to take on all factory lighting offered to it; that it is obliged to take a certain amount which is inherently unprofitable; that it should minimize this amount by first advising the customer how to reduce his demand by utilizing light to best advantage; second, advocation of the transfer to daylight hours of any power load that can be dispensed with during the evening hours; and third, by passing over to the gas company such factory space lighting as can be profitably furnished by gas arcs, retaining for electricity the long-hour localized lighting.

The above paper shows that all lighting is not desirable where the rates are fixed and cannot be altered to suit any prospective customer. What is needed is a definite rate of charge for electric energy that fulfils all conditions. For the power station considered above, it is apparent that the rate of charge for the demand is too small, and the rate of charge for the supply which exceeds the minimum allowable use is too large. While 16 cents per unit is usually considered a high figure, it is not high for a demand averaging one hour daily, and will usually be found too small, as in the above case.

LUMINOUS ARC LAMPS FROM THE STANDPOINT OF CENTRAL STATION OPERATION.

Howard Grabill gives an account of the results obtained by the Ashland Gas & Electric Light Company with magnetite or luminous arc lamps. This installation was made in December, 1905, and consisted of 90 type 2 lamps, the rate for energy on a midnight moonlight schedule being $68 per lamp per year.

As open arc lamps were formerly used for lighting the streets of Ashland, the paper is in the nature of a contrast between that lamp and the magnetite lamp.

The distribution of light is said to be very good about the magnetite lamp. There is almost no shadow beneath the lamp. Measurements show that the illumination about the magnetite lamp is more intense than that about an alternating current series lamp, but no data is given as to what types of lamps were compared. The quality of the light is also very good. Another advantage which this lamp has is that of fewer outages. When a lamp is found to not be burning it can usually be started by raising the rope by which it is raised or lowered. Chances for broken globes are reduced on account of the long-burning feature, since frequent trimming is unnecessary. The ratio of outages as compared with the carbon lamp is given as 1 to 3 in favor of the magnetite lamp.

This company is using a direct-current system, energy being furnished by a Brush arc machine. They replace a 480-watt lamp with a magnetite lamp consuming about 320 watts.

The upper or positive electrode is a heavy piece of copper. It is reversible and has a life of about 4000 hours. The lower electrode is an iron tube 5/8 inch in diameter and 8 inches long, filled with black magnetic oxide of iron and has a life of 175 hours. It is thus necessary to trim these lamps only nine times a year. The cost of maintaining these electrodes on a schedule such as given is about 60c. per lamp per year. Adjustments are easily made. Repairs and renewals cost about 54c. per lamp per year. It is expected that with the type 3 lamp the last item will be reduced.

REPORT ON ELECTRIC HEATING DEVICES.

The reporter, Mathias E. Turner, has deemed it best to confine this report to electric heating appliances for household purposes.

The first general criticism is that most electric heating devices are too slow in heating. What is needed is a higher temperature during the first few minutes. The second general criticism is that the methods used for attaching the appliances to the electric circuit must be improved.

Immersion coils for boiling clothes in a clothes boiler are conveniently connected to a receptacle by a fixed flexible cord and a three-heat push plug. Laundry irons of 6 pounds weight and single heat are perhaps best adapted to general household use. A switch located on the iron is a simple and effective method of regulating the heat for ironing different materials.

The electric oven with heaters at top and bottom is a superior baker but decidedly wasteful of heat. A proficient chef stated that it was the best baker he had ever used, but this piece of apparatus wasted so much heat that because of its expensive operation the electric cooking development is somewhat retarded. The oven should be very much better heat insulated; it should heat to a sufficiently high temperature in about ten minutes and maintain a temperature suitable for most baking purposes with a consumption of not more than 250 watts per hour.

In a particularly well equipped kitchen an electric cooking outfit replaced a gas range excepting only a vertical gas boiler. Later a vertical electric boiler was tried with success.

Other kitchen utensils compare very favorably with similar appliances heated by means other than electric.

Lately there has been put on the market an instantaneous water heater. This device, together with all the other electrical heating appliances, now make it perfectly feasible to specify in the house-building plans special heating circuits and single-pipe water systems for the exclusive use of electricity in all the duties usually performed by other illuminants and fuels, excepting only winter heating.

The applications of electric heat in the sick-room is now almost indispensable. It offers a ready means for quickly and safely boiling small quantities of liquids in portable vessels, in sterilizing articles and in vaporizing medicines. The heating pad has also won many friends for electricity. Reliable data was collected from eleven homes using complete cooking outfits.

The cooking in the eleven residences was done at a 5c. rate, and the expense under these conditions compares favorably with artificial gas.

CO-OPERATIVE COMMERCIALISM IN THE ELECTRICAL FIELD.

This paper, presented by J. Robert Crouse, will be found reprinted in full on another page of this issue.

WHAT IS THE BEST FORM OF POWER FOR STATIONS OF 500 KILOWATTS CAPACITY OR LESS.

Prof. F. C. Caldwell stated that there are now available the following types of apparatus, direct-current two-wire, 220-volt, and three-wire, 110-volt, also alternating current single phase or polyphase. The choice between these depends on the character of the load to be supplied, upon the size of the plant, and upon the conditions under which it will be operated. The development of the metallic filament incandescent lamp is stated to be a reason for going to 110 volts. The low resistance of metals as compared with carbon make the extension of these lamps to voltages as high as 220 seem improbable. The other factor is the placing on the market of successful three-wire generators at a cost not greatly in excess of the standard two-wire types. Where power is the main business it is doubtless that the 220-volt system will continue to be employed, but where lighting is an important matter the problem may be narrowed down to a question of three-wire direct current *versus* alternating current, single phase and polyphase. Between the direct and the alternating current the question of distribution of load is the most important factor. Where the territory covered is large the decision must be in favor of alternating current. On the other hand, where the conditions seem to set definite and comparatively narrow limits to the area which the plant will supply, the greatest simplicity, higher economy in distribution and superior regulation usually obtained from direct-current plants, may determine in favor of this form of supply.

The question of the use of single or of polyphase alternating current is also an interesting one. Single-phase motors are obtainable in sizes running up to about 30 horse-power, so that where the supply of power in large units is not to be anticipated, as, for instance, in the case of a strictly farming community, much is to be said in favor of the greater simplicity of the single-phase system.

Turning next to the question of prime movers, the following classification will be useful:

I. Water power.
II. Gas power:
  Natural gas.
  Producer gas.
III. Steam power:
  Reciprocating engines.
  Turbines.

In regard to water power nothing need be said further than to predict that before many years much more electrical energy will be developed in Ohio by water power than is now done.

Where natural gas is available there is hardly room for any further discussion on the subject, since the gas engine thus operated is superior to all other forms of heat engines.

In the absence of either water or natural gas the producer and gas engine plant is in free competition with the various forms of steam engines, with a strong indication that the odds are coming to be more and more favorable to the former.

So far the great development which the turbine has shown in the case of the larger stations has not been much felt by the smaller, although at present turbines in a variety of small sizes are available. Their use does not show as great an advantage over the reciprocating engine as in the large sizes. Generally speaking also in the case of the small station economy of space is not so vital a matter as with the large city plant On the other hand, the simplicity of the turbine would be a matter of even greater consequence, so that the question of relative first cost would probably be a determining factor in most cases.

Of course wherever condensing water is available in ample quantity anything but the very smallest plant should be operated with compound condensing machines. The availability of condensing water would also be important in determining the use of turbines.

The use of artificial means for the cooling of the condensing water, such as towers or reservoirs, is a financial one, and depends largely upon the price of coal, the cheapness of which in Ohio would seldom permit of the use of this system.

Another factor which has always received consideration and which may at times determine the character of the steam plant is the sale of exhaust steam for heating purposes. The jacket cooling water in a gas engine plant may be similarly used.

In the case of small lighting and power plants their combination with some other form of industrial activity should be given consideration. In many cases a power plant may be made to pay if during the daytime the energy of the plant can be consumed in the operation of some productive industry. This works out especially well where the industry is of such character that a part at least of its machinery can be closed down an hour or two earlier during the winter months without seriously interfering with its success. A combined electric and pumping plant is a similar case. This is an especially desirable arrangement if water storage is available, so that the pumps can be entirely shut off during the period of peak load. In this connection the electrically driven centrifugal pump which has recently come before the public ought to prove useful.

HELPS TO A SOLICITOR AND WHAT 50 CENTS' WORTH OF ELECTRICITY WILL DO.

Several examples of electric application are given by A. S. Miller with special reference to the operation in hours per month. Among the examples given are: A ¼ horse-power motor is large enough for any ordinary residence for operating a washing machine and three hours is generally required to complete the work. With a motor of that size 50 cents' worth of electricity will do eight washings. This machine also wrings the clothes.

A six-pound iron, which is the size for general household, consumes 500 watts per hour or 5 cents' worth of current per hour, if current is on continuously. As a matter of fact the current will be used about half the time, so the cost will be from 2½ cents to 3 cents per hour. Fifty cents will pay for two weeks' ironing.

A 12-inch fan would be appreciated during the summer months, and be useful as well, as on many days it is raining at the times the clothes are ready to put out to dry, and if hung in the house the fan would be a great aid to drying them quickly. The fans can be operated for 3½ hours a day for thirty days for 50 cents.

Another excellent thing to arouse interest is the sewing machine motor. It can be readily attached to any make of machine, and the cost is so small that it would hardly be noticed, especially in a residence where each season's clothes are made in a week or two. The ordinary household motor for sewing can be operated three hours for one cent, or a full two weeks' sewing can be done for 50 cents. The porch light is given as another instance of convenience; also it is a great protection as it permits of seeing who is on the porch before unlocking the door. The cost of operation is given as 50 cents for two months, burning three hours every night.

The heating pad is mentioned as being of great value in cases of sickness. If used steadily for three hours every night for thirty night 50 cents will pay for the current consumed. Among other examples are those of numerous cooking utensils in which the absence of dirt is brought forward as a very strong argument. The remainder of the paper is devoted to special applications of small power motors to the operation of different machines.

BEST WAY TO MEET GAS AND GASOLENE COMPETITION.

The portion of this paper by F. H. Golding brings forward the desirable feature of free lamp renewals and free maintenance of the wiring equipment by the majority of central stations as a good talking point in competition with the cost of gas lighting where the mantles must be supplied by the customer. The most serious obstacles met with in gas competition is the expense of installing electrical work.

Samuel Rust states that the time devoted to cleaning and repairing gasolene or other apparatus is generally considered unimportant by the business men in smaller towns. The business man's view of this matter is that their employees might as well be doing this work when they have the spare time, and the cost is unimportant. The dangerous character of gasolene outfits is mentioned as a strong factor against their use.

Examples of a clipping bureau are given by W. E. Russell in the same paper.

Arthur Pomeroy gives data on the cost of operating gas engines, taking into account the water used for cooling. Among the data given is that for a 30 horse-power engine running ten hours a day, as taking 3000 cubic feet of water per horse-power a year and 12 gallons of lubricating oil. Depreciation varies between 10 and 35 per cent. Natural gas of 1000 b. t. u. is consumed at the rate of 15 cubic feet per i. h. p. hour, but the statement is made that under ordinary operating conditions an engine will consume about 30 cubic feet per i. h. p. hour.

When artificial gas is used, the consumption will be from 20 to 28 cubic feet per i. h. p. hour, or from 53 to 75 cubic feet per kw. delivered, the variation being due to the different qualities of gas, which depends upon the method of manufacture.

The question of rates is considered by E. T. Selig as important when competing with natural gas. His company adopted the following system of rates:

For the first kw. hour consumed each month for each light or equivalent of maximum demand, 15c. per kw. hour.

For the second kw. hour, 10c. per kw. hour.

For all over two kw. hours per light, 6c. per kw. hour.

A minimum bill equal to 15c. for each light of maximum demand, but in no case less than $1.11 was charged.

A discount of 10 per cent. was allowed on all bills at the above rates, if paid by the 10th of the month.

A system of free renewal of lamps growing dim or burning out in service was established, making a charge of 25c., however, for the first installation of lamps and for all renewals of broken lamps. Only lamps obtained from the company are renewed in this way, contractors and others being prevented from furnishing a low-grade lamp.

By using gas under the boilers the fuel cost was cut to half that of coal, besides dispensing with the services of several firemen; therefore natural gas is regarded as an advantage rather than a detriment to the electric lighting business.

Review of the Technical Press

Advantages of Electric Motors

ONE of the great advantages attending upon electric operation is the enormous saving in space, a point of material importance where land values are high. The *Financial Times* realized this some time ago, when in order to cope with its rapidly extending business it had to erect another large printing machine. The ability to accommodate this machine was only obtained by removing the engines and boilers formerly operated.—*From the Electrical Bulletin, of London.*

Speed of Flicker Photometers

An article appearing in the *Electrician*, of London, of May 31st, by J. S. Dow, gives an account of experiments to obtain an exact critical speed at which flicker photometers are accurate. The results are plotted in the form of curves with percentage variation of illumination detectable by photometer as ordinates and frequency of flicker as abscissa. He finds that the intensity of light should be 5 candle meters or more, and that the frequency of flicker should be between 500 and 1000 to obtain accurate results when comparing two sources of white light. Results of tests are also given in which comparison is made between green light and white light; these are not, however, definite in amount.

In conclusion, he says the range of frequency over which the sensitiveness of the photometer is at its best when comparing lights of the same color is sufficiently great to make it an easy matter to select a satisfactory speed; this speed should answer over the range of illuminations met with in ordinary work, but if the illumination is very low a lower speed is necessary, and a diminished sensitiveness may be expected.

When comparing lights differing widely in color a higher speed is required, and the satisfactory range of speed is much more restricted. It is, therefore, not so easy to strike the exact correct speed, but a little practice enables it to be found by trial without much difficulty. Finally, it should be noted that very great exactness cannot be expected from experiments of the nature described. The sensitiveness of the eye to a flicker seems to be easily altered, and is particularly susceptible to the effects of fatigue. One would, therefore, expect results obtained on different days to differ somewhat, and this has been the writer's experience. It is also inevitable that in the course of the long series of readings which such an experiment demands the element of fatigue should be present. The repetition of these experiments, however, has always led to the same general results. Lastly, it must be noted that the eyes of different observers do admittably differ considerably in their perception of flicker, and the legitimate deductions from these experiments are therefore limited by the fact that they were obtained for the writer's eye only.

Dublin Exhibition

The *Electrical Times*, of London, of July 11th, gives a description of the exhibition at Dublin. The grounds of the exhibition cover 50 acres; the electric lighting and power installations are as follows:

STEAM PLANT.

One 400 kw. direct-driven set consisting of vertical enclosed type triple expansion engine by Messrs. Combe Barbour, of Belfast, coupled to a direct-current multipolar generator of Westinghouse manufacture; speed, 330 r. p. m.; voltage, 230 volts.

One 300 kw. direct-driven set consisting of vertical type cross compound engine, also by Messrs. Combe Barbour, fitted with Corliss valve gear and driving a Westinghouse direct-current generator on the main shaft placed between the center lines of each cylinder; speed, 90 r.p.m.; voltage, 500 volts.

Two 70 kw. direct-driven sets, consisting of vertical enclosed compound engines by Messrs. Workman, Yeames, of Belfast, coupled to direct-current generators made by the General Electric Company, Witton; speed, 550 r.p.m.; voltage of generators, 230 and 460 volts, respectively.

GAS PLANT.

One 250 kw. direct-coupled set, consisting of horizontal two-cylinder gas engine by the National Gas Engine Company, driving a direct-current multipolar generator by Messrs. Siemens Bros.; speed, 180 r.p.m.; voltage of generator, 220 volts.

One 100 kw. belt-driven set, consisting of 175 b.h.p. single cylinder gas engine by Messrs. Crossler Bros., driving by belt a direct-current dynamo by the General Electric Company; speed of engine, 100 r.p.m.; voltage of generator, 220 volts.

The visitor will kindly not consider the plant as a sample installation, but rather examine the merits of the individual units composing it; the Irish-built engines being well worthy of attention in this respect.

The boiler house contains three of the latest well-known Babcock & Wilcox multitubular boilers fitted with close link chain grate stokers and improved form of combustion chamber. Superheaters are fitted to each boiler, superheating the steam about 160° F. Two induced draft fans by Messrs. Musgrave & Company, of Belfast, electrically and steam driven, respectively, are used.

The plant is worked non-condensing. Feed water heaters have been supplied by Messrs Babcock & Wilcox.

Among the electrical exhibits are: Messrs. W. T. Henleys Telegraph Works Company, Ltd., who show specimens of all classes of extra high pressure and low pressure electric power and lighting cables, telegraph cables and accessories. The Indiana Rubber, Gutta Percha and Telegraph Works Company, Ltd., have also an interesting exhibit of electrical testing instruments, cables and other manufactures. The Robertson Lamp Company are showing their well-known lamps in process of manufacture. The Westinghouse Company, in addition to the generator plant already mentioned, exhibit an improved type of tramway controller which is remarkable for its accessibility and the ease in repairing its working parts. A working model of a push-button electric lift by Messrs. Waygood & Company, fitted with Westinghouse gear, is also on view. The Westinghouse Company also exhibit improved and compact forms of oil and other circuit breakers, and a few types of motors. Messrs. Babcock & Wilcox, in addition to the up-to-date boiler-house plant already mentioned, exhibit an improved form of coal conveying plant. Messrs. W. H. Allen & Company, Ltd., of Bedford, exhibit examples of their enclosed type high-speed engine suitable for direct coupling to direct or alternating-current generators. Le Carbone Company have an exhibit of dynamo and motor brushes and other accessories. Messrs. Musgraves, in addition to the induced draft fans installed in the boiler-house, exhibit electrically-driven fans for various other purposes. Messrs. Green & Company exhibit examples of air heaters and economizers, together with improved types of force pumps, etc. Messrs. Carron & Company show various kinds of electrical ovens and cooking utensils. Messrs. D. Santoni & Company have upward of a hundred of their well-known flame arc lamps distributed about the grounds and buildings. The D. P. Storage Battery Company exhibit types of their storage cells and plates.

The wiring of the exhibition has been carried out by Messrs. William Coates and Son, of Belfast and Dublin, the main switchboard being constructed by the General Electric Company. The busbar pressure at the main switchboard is 220 to 230 volts. Ninety 10-ampere arc lamps, run 9 in series, illuminate the Central Palace, and are supplied with a pressure of 460 volts. Some 16,000 volt 8-candle-power incandescent lamps are used to outline the main central building and dome, the art galleries and the bridges over the lakes. These lamps are run 5 in series on a supply pressure of 500 volts. A throw-over switch situated in the central buildings and consisting of two large liquid motor starters coupled enables the color of the lighting to be changed from white to red, and vice-versa, upon these buildings with very effective results. The use of a pressure of 500 volts upon these circuits, while effecting considerable economy in first cost of wiring, results in ugly gaps in the lines of light where a lamp fails or a connection is defective.

The Charing Cross, Euston & Hampstead Tube Railway

The formal opening of this latest London "Tube" railway is announced in *Electricity & Electrical Engineering*, of July 12th. The new line extends from Charing Cross to Golders Green at the junction of North End Road and Finchley Road. The line of route passes under Leicester Square, Oxford Street, Tottenham Court Road, Euston Road, Euston, Mornington Crescent, Camden Town, Chalk Farm, Belsize Park and Hampstead, at each of which places there is a station. A branch line which leaves the other at Camden Town Station extends by way of South Kentish Town, Kentish Town and Tufnell Park to Highgate, the northern terminus of the line.

The tunnels and permanent way are practically identical with the former tubes, each tunnel being lined with cast-iron erected in sections which are bolted together and subsequently lined on the outside with a grouting of lime, which forced in under pressure fills the space intervening between the iron and clay walls. Grades are between 1 in 60 to 1 in 120. Elasticity of the track is secured in a somewhat novel fashion. The sleepers of incombustible Australian Karri wood are laid on a concrete foundation which is somewhat narrower than the length of the sleepers which consequently overlap either end, and it is upon these projecting portions that the rails are actually laid. In addition, the chairs supporting the rails rest on pressed wool-felt pads, which assist in the elimination of noise and vibration.

The power for working the line is derived from the main power station at Lots Road, Chelsea, and is distributed to the line from five substations, of which one is common to the District and Baker Street tubes. The remaining four substations have a total capacity of 7200 kw.

The Westinghouse signaling system has been adopted. A feature of this system is an illuminated track diagram upon which the operator can trace the position of any train in his section at a glance.

The rolling stock consists of 60 motor cars and 90 trailers, a train consisting of two motor cars and three trailers. Each motor car seats 46 passengers and each trailer 52. A feature of the braking arrangement is the adoption of Frood's patent brake block insets consisting of compressed canvas and pitch. These blocks, which wear more rapidly than the usual cast-iron brake shoes, are free from the liability of interference with the signaling arrangement through the creation of iron dust in the tunnels.

A complete multiple unit electrical equipment for one motor car is erected in full view of the pupils in the training school. Supplementing this practical model is a large scale diagram of connections. The importance of a thorough education in brake operation is not overlooked, for the equipment includes a complete air-brake apparatus.

The Steam Turbine

An article by C. P. Steinmetz appearing in *Cassier's Magazine* gives a discussion and elementary theory of the steam turbine, starting with examples of overshot, reaction and impulse water wheels. Then he takes up the reciprocating steam engine and the thermal engine. After this he starts in with the example of water coming from a stationary nozzle, and impinging on an impulse type of bucket wheel.

His conclusions are that the most efficient peripheral speed of the reaction turbine is a speed equal to the spouting velocity of the jet, while the most efficient peripheral speed of the impulse turbine is equal to one-half the spouting velocity of the jet. With a combination turbine the most efficient speed is between the two values or more than half and less than the full spouting velocity of the jet. The impulse turbine, therefore, with the same spouting velocity requires a lower peripheral speed than the reaction turbine. He says: "The peripheral speeds of moving apparatus are usually between 3600 and 7200 feet per minute. At speeds higher than this, centrifical forces become serious and require special consideration." Economical boiler pressures are given at about 175 pounds absolute, and condenser pressures from 2 to 1 pounds absolute, or as usually expressed, 26 to 28 inches.

The available energy of expansion of one pound of steam from 175 pounds to 1 pound absolute is 254,000 foot-pounds, which gives a spouting velocity of 4030 feet per second. The problem which had to be solved in developing the steam turbine was to utilize such velocities mechanically. The first successful attempt in designing an efficient steam turbine was made by DeLaval by using extremely high peripheral speeds, 800 to 1000 feet per second. He succeeded in abstracting by a single turbine wheel from a steam jet with single expansion from boiler pressure to condenser pressure sufficient energy to give an efficiency comparable with that of the best reciprocating steam engine. To overcome the unbalanced forces at such high speeds, DeLaval made the wheel self-balancing by adopting a long, thin and flexible shaft which centered itself, that is, the disc is a gyroscope making its own axis of gyration. The difficulties of obtaining a balance by this means increase with the increasing size of the turbine; therefore, the DeLaval turbine has been mainly built for small and moderate-sized units. The solution of this problem is given in the form of adopting successive expansion steps.

With the modern development of high-speed machinery the statement is made that peripheral speeds as high as 400 feet per second, and even higher, are used in turbine wheels. One objection to the increase in number of steps is the friction loss of the steam in the wheel passage. He concludes with the statement that the proper distribution of the energy between pressure steps or stages and velocity steps of wheels per stage required to produce maximum economy is a question of design and outside of the article.

Concrete Telegraph Poles

The paper read before the Association of Railway Telegraph Superintendents in convention at Atlantic City, June 19, 1907, by G. A. Cellar, is reprinted in the *Cement Age* of August. The paper starts in with a discussion of the qualities required for the telegraph pole, and then goes on to state the different kinds of woods used for these poles, giving the opinion that wood when readily obtained gives the most economical result. The northern cedar is placed first as combining reasonable strength with resiliency and almost ideal tapering necessary to afford the maximum strength at the point of greatest pressure. Next the chestnut is mentioned as being used extensively in the middle east because it has a long life in contact with the soil. On the Pacific coast sawed redwood posts are stated as being utilized quite extensively, while in Mexico the procedure is to cut a piece of timber with rectangular section diagonally across its broader side from near one side at one end to near one side at the other end, making of each section two posts each of large base and small top. This form of support has also been used by halving I beams in the same manner.

The northern cedar as a proposition for the supply of the immensely extended telegraph, telephone and light and power lines has passed the safety line. The western cedar, of which there are immense quantities, is so far away that the transportation charges make the price per pole almost prohibitive for ordinary purposes. The chestnut, considered as a supply for its native regions, is to be depended upon for the immediate future, but is sadly inadequate as a supply for the whole country.

The principal point of decay in wooden poles is at the ground and air line where the alternate drying and dampening induces a condition of decay which grows and frays the body of the pole until the pole is so weakened that it has to be reset or replaced. The frequent fires in some districts are also given as a cause for the short life of the wooden pole.

In looking about for a product one naturally feels that the best manufactured article will be steel, but consideration develops that the length of life of steel without adequate preservative agencies is not much greater than the long-lived woods. The statement is made that steel poles, to have a sufficiently long life for consideration, must be treated on the inside as well as on the outside.

So far as the writer has ascertained the preservation of steel imbedded in properly constructed concrete is perfect. Concrete not only does not disintegrate but hardens and improves with age. Therefore, the life of a structure of reinforced concrete is practically unlimited, and a telegraph pole made of reinforced concrete ought to endure for many generations, and answer the purpose for which it was erected. Tests are given as made on concrete poles which were reinforced with four ¾-inch round bars, each 24 feet long and four ⅝-inch round bars of the same length. The poles were 8 inches in diameter at the top, and 13 inches at the base, having a taper of 1 inch to 5 feet. Galvanized iron steps were screwed into wooden blocks molded into the concrete, and holes were left for through bolts for supporting the cross arms. The cross-arm braces were attached to the arm by through bolts, and fastened to the pole with ordinary lag bolts driven into the wooden plugs which were placed in the concrete at the proper places. The concrete poles were set to a depth of 5 feet in concrete, and after standing long enough to permit the cement to become solid, they were tested in the following manner:

An iron clevis was placed around the pole to be tested 10 inches from the top, to which wire rope was attached leading over a pulley placed at the same height and at an equal distance from the pole, and fastened to a differential pulley block, which was attached to a laboratory weighing machine; the results are shown in the tables.

After the cement poles had been broken, the reinforcement so held them that it required almost the breaking pressure to further deflect them from their slightly inclined position.

The mixture used in these cement poles was 1 to 3. They were constructed in cold weather and through some mischance at the last moment suitable gravel could not be obtained. Pole No. 1 was found to have a defect in the casting which is believed to be the cause of its early rupture. Pole No. 2 gave a very much better result.

The consensus of opinion seems to be that a 1:2:4 mixture is the best for use in this class of construction, and while the experiments were entirely satisfactory in the development of the problem, the hollow pattern is not considered to be the highest type desirable, that is, to combine strength with the least possible weight in order to obtain ease in handling, and that the removal from place to place may be readily feasible.

To fulfil these requirements the poles should be made with a superstructure of somewhat greater strength than the wires which it is required to support, joined to sufficiently added strength by reinforcement and added area in the base, especially at the ground line, and the base should be reinforced in the most effective way to withstand the extreme pressure at the point of fulcrum.

POLE No. 1, CONCRETE OCTAGONAL.

Length.	Base Diameter.	Top Diameter.	Depth in Concrete Anchorage.	Distance from Point of Fulcrum to Point of Load.
30 feet. . . .	14 inches.	8 inches.	5 feet.	24 feet 2 inches.

Deflection at Top.	Load Pounds.		Deflection 12 inches above Ground Line.	Time.
		TEST No. 1.		
3¾ inches. . .	1,830	. . . .	$\frac{1}{32}$ inch	3:17
5¾ inches. . .	2,230	. . . .	$\frac{1}{16}$ inch	3:18
		TEST No. 2.		
½ inch	50	Temporary deflection, ½ inch.	$\frac{1}{32}$ inch	
8 inches. . . .	2,630	. . . .	⅛ inch	3:19
11¾ inches. . .	3,030	Crack No. 1 and 2.	$\frac{3}{16}$ inch	3:20
		TEST No. 3.		
1¼ inches. . .	50	Temporary deflection.	$\frac{1}{16}$ inch	
14¼ inches. . .	3,430	Crack No. 3 and 4.	¼ inch	3:24
18 inches. . .	3,210	Crack No. 5 and crushed bolt.	⅜ inch	3:25
25½ inches. . .	3,150	Pole broke at ground level.	¾ inch	3:26

POLE No. 2, CONCRETE, SQUARE.

Length.	Base Diameter.	Top Diameter.	Depth in Concrete Anchorage.	Distance from Point of Fulcrum to Point of Load.
30 feet.	13 inches	7 inches.	5 feet.	24 feet 2 inches

Deflection at Top.	Load Pounds.		Deflection 12 inches above Ground Line.	Time
		TEST No. 1.		
¾ inch.	50	. . . .	. . . .	2:02
2½ inches. . .	1,830	. . . .	. . . .	2:04
3½ inches. . .	2,230	. . . .	. . . .	2:08
		TEST No. 2.		
¾ inch.	50	Temporary deflection.	1 inch	
4$\frac{9}{16}$ inches . .	2,630	. . . .	. . . .	2:10
8½ inches. . .	3,030	. . . .	$\frac{1}{16}$ inch	2:11
		TEST No. 3.		
3½ inches. . .	50	. . . .	. . . .	. . . . . .
31 inches. . .	3,290	. . . .	. . . .	. . . . . .
34½ inches. . .	3,430	Crack No. 1.	⅛ inch	2:14
		TEST No. 4.		
21¼ inches. . .	50	Temporary deflection.	22 inches	
39 inches. . .	3,690	Crack No. 2, 3 and 4, Pole crushed. . . . . crack at ground level.		

Wireless Telephony

Results obtained at Put-in-Bay, in Lake Erie, during the week of July 15th to 20th, are given by Lee De-Forest in the *American Telephone Journal*, of August 10th. The yacht equipped with the telephone apparatus followed yachts and motor boats around the course during the regatta of the Interlake Association, and accounts of occurrences during the races were telephoned to the shore station exactly as events occurred. The greatest distance at which reports from the yachts were heard was four miles.

Study of Telephone Generators

T. W. Wilder gives an account of a test on ten telephone magneto generators furnished by ten different manufacturers in the August number of *Sound Waves*. The ten generators were all of the same class or style, being five-bar machines for use on bridging telephones or rural party lines. They were taken from the regular stock of each manufacturer. The shape of the curves giving the voltage with different positions of the armature are plotted and illustrated by a series of curves. He states the desirable features of the different machines on inductive and non-inductive load and which are particularly good in case the ringing circuits contain condensers. Other machines are shown to give particularly good results for selective ringing with biased ringers. The curves for the ten machines are averaged and shown as a composite curve which might be considered as the performance of the average machine as represented by ten different manufacturers.

Selenium Cells

In the July *Proceedings of the American Institute of Electrical Engineers* is given an account of selenium cells by R. A. L. Snyder. Among the properties of selenium is mentioned the quality that after being melted and quickly cooled, selenium assumes a translucent vitreous formation, and upon being held to the light will have a dark red color. While in this condition it is a dielectric and can be electrified by friction like glass; if, however, the molten selenium is cooled slowly, it will assume a gray, crystalline formation, become opaque to light and will then conduct electricity. According to the electromagnetic theory of light, it would not conduct electricity did it remain translucent, as it is a well-known fact that all conducting metals are opaque to light.

Alexander Graham Bell took advantage of this property of selenium to invent a wireless telephone. This instrument, known as the photophone, transmitted speech over a beam of light. From 1880 to 1881 Professor Bell with Sumner Tainter took out six or more patents on the photophone and selenium cells. These patents cover practically all the now known properties of selenium. Improvements in cells since that time have dealt principally with their practical applications to various purposes rather than to any scientific investigation.

The photophone consists of a transmitter for varying the intensity of a beam of light by means of sound waves impinging upon it and a receiver for converting the light waves at a distant point back into sound waves.

A statement is made that Herr Ruhmer photographed sound waves from a speaking arc upon a celluloid film and reproduced the sounds by passing the film between a source of light and a selenium cell in series with a battery and telephone receiver.

The use of selenium as a measure of light intensity is mentioned. Selenium changes its electrical resistance in proportion to the amount of light falling upon it. If the selenium is in the form of a cell with a current flowing through it, the current will vary according to the resistance, or in proportion to the amount of light falling upon the cell. Any change in the current can be easily measured with our present instruments, thus making a direct reading photometer. The one great objection to the use of selenium as a photometer is that its resistance gradually changes.

Numerous patents have been taken out for picture transmitting apparatus based on the use of the selenium cell; just how valuable they are remains to be seen.

Elements of Electrical Engineering

The *Western Electrician*, of August 31st, contains a continuation of Elements of Electrical Engineering, by George R. Metcalfe. This issue gives the different connections for incandescent and arc lamps, showing the series and multiple systems of distribution, multiple distribution with feeders, mains and distributing lines, the three-wire system with two generators, three-wire system with balancing set, and the three-wire system with balance coils.

Kern River No. 1 Power Plant

The continuation of the description of Kern River No. 1 Power Plant of the Edison Electric Company, of Los Angeles, is given in the *Electrical World*, August 31, 1907. The article starts in with a description of the transmission towers. The data given for calculating strains on the towers is taken on a basis of a wind pressure of 30 pounds per square foot on the tower and the wire of a 700-foot span. The towers will also withstand absolute failure of any single wire, even though none of the resulting strain is transmitted to adjacent wires. There are nine insulators, spaced on six-foot centers, five on the upper of two cross-arms, and four on the lower, the arms consisting of 9-inch 13¼-pound channels. A standard 60-foot tower is 12 feet square at the base, the uprights are formed of 4-inch angles and the cross braces of 2¾-inch, 3-inch and 3½-inch angles, the diagonal rods being 11/16-inch and ⅝-inch in diameter. Four insulators for the telephone lines are mounted on one cross bar twenty-one feet above the ground. Forty of the towers were made extra heavy for use at points where the line changed its direction.

The insulator pins are of cast-steel, and were furnished as a part of the tower. They are secured to the tower by four bolts and are cemented into the insulators.

The transmission line is designed to consist of three circuits with wiring spaced symmetrically on six-foot centers. This wire is 7 strand 4-0 hard drawn copper, having an elastic limit exceeding 35,000 pounds total, and an ultimate strength of 62,400 pounds.

The insulators are stated to be the largest yet made for commercial transmission purposes. They are 18 inches high, and 8 inches in diameter at the grooved top. The top section is 18 inches in diameter, and the two lower petticoats are respectively 14 inches and 11 inches in diameter. Each assembled insulator weighs 50 pounds. They are light gray in color to harmonize with the color of the towers. Specifications called for a guarantee of a 100,000 volt test from the groove to the pin for half an hour under a precipitation of one inch in five minutes at an angle of 30 degrees from the vertical. The assembled insulator was required to withstand a wet test of 150,000 volts for 30 seconds, and the separate parts are guaranteed to withstand a voltage of 25 per cent. in excess of the normal proportion of over-voltage test. The insulators are guaranteed to withstand a side strain of 4000 pounds, and actually fail at approximately 9000 pounds.

The article then goes on to describe the switching stations and substations, touching on the hydraulic features.

The Pacific Electric & Los Angeles Interurban Railway

From *Electric Railway Review* of August 31st. The lines of the company are shown on a map drawn to a scale of approximately six miles to the inch. Considerable space is devoted to the roadway and pole line construction, several views of the line being shown. An interesting method is given for preserving the butts of the poles; this requires the use of crude petroleum to the amount of from 7 to 10 gallons per hole. The oil is well mixed with the dirt, as it is tamped about the pole, and this mixture serves to preserve the wood by keeping away moisture and insects; poles which were protected by this method and have been in service more than five years exhibit no signs of decay.

Hydraulic Formulæ

Adolph Black gives a complete set of formulæ for the discharge of water through different shaped openings in the *School of Mines Quarterly*. Different shaped openings are taken up in order, and the formulæ developed in line with papers presented before the American Society of Civil Engineers, and in different technical papers. The article concludes with the quotation: "It is hardly worth while to pursue this subject still further into space where we have absolutely lost the guidance of experimental light. Such speculations, while possibly ingenious and plausible, when tested with facts generally prove to be very wide of the truth."

Improved Condenser Connections

"It has been observed that a condenser may be doing good work, but that indicating gages and mercury columns located 50 feet from the condenser or the exhaust valve of the engine can scarcely be expected to tell the whole story. It is better to have indicating apparatus close to the condenser and also close to the exhaust ports of the engine. The first will tell what the condenser is doing, and the latter what vacuum is effective where it is needed." The above quotation is taken from the *Electrical Traction Weekly*, in an article by R. D. Tomlinson. He then goes on to state that in one case the loss between the condenser and exhaust nozzle of the engine was 10¼ inches, and gives a series of tests at different parts of the piping. Other examples are shown of both good and bad practice in piping from the engine to the condenser.

Cos Cob Power Station The New York, New Haven & Hartford Railroad Company

A description of this power station appears in the *Street Railway Journal*, of August 31, 1907. The station, in addition to furnishing single-phase current for the operation of electric trains over the New Haven Railroad, also delivers three-phase current to the Port Morris power-house of the New York Central to compensate for the energy required to operate the New Haven trains over the line of the New York Central system. The location is such that coal can be delivered either by water or rail, and an unlimited amount of salt water for condensing purposes is available. A pure feed-water supply is obtained by erecting a dam about a mile from the power-house.

The initial generating equipment consists of three multiple expansion parallel flow Parsons steam turbines. Provision has been made for the installation of a fourth unit of corresponding size. The turbines are rated at 4500 b.h.p. each, and the generators at 3000 kw. at 80 per cent. power factor. The turbines are operated at 1500 r. p. m. by steam at 200 pounds pressure, and 100 degrees superheat. The continuous overload capacity is 50 per cent. and momentary overloads of 100 per cent. can be taken care of when operating condensing. The turbines are equipped with the latest accessories in the way of automatic safety stops, water packed glands for the turbine shaft, adjustable water cooled bearings, and a continuous circulation oiling system.

As the requirements necessitated the generation of three-phase current for delivery to the New York Central system as well as single-phase current for the operation of the electric locomotives over the New Haven Railroad the generators are wound for three-phase current, but arranged for the delivery of both three-phase and single-phase current. The generators are entirely enclosed by a casing into which air is drawn through suitable ducts from a fresh air chamber, and from which the air is discharged through other ducts into the basement. This system of generator ventilation renders the operation of the generators practically noiseless. The excitation of the generator fields is provided by two 125 kw. direct-current generators, direct-connected to Westinghouse engines, and one motor-driven exciter.

A separate condensing outfit is provided for each turbine. To prevent the rapid deterioration of the brass condenser tubes by the galvanic action which usually occurs where salt water is employed, a motor generator set has been installed and provided with suitable controlling apparatus for maintaining in each condenser a counter electromotive force slightly in excess of the electromotive force due to the galvanic action.

The initial boiler installation consists of twelve 525-horse-power Babcock & Wilcox water-tube boilers set in batteries of two boilers each. Provision is made for four additional boilers to take care of the fourth generator unit.

A novel feature of the boiler settings is the installation of an external steel casing entirely enclosing the brickwork, thus rendering the settings impervious to air leaks.

Three Green fuel economizers are provided and the boiler flues leading to the economizer are arranged with by-passes so that one or all of the economizers can be cut out.

Possible Electrification of a Division of the Southern Pacific R.R.

The *Electrical Review*, of August 31st, contains a notice that the Southern Pacific Railroad is considering the question of electrifying a division of 136 miles in length from Rockland to Sparks across the Sierra Nevada mountains. The road is single track and the traffic is very heavy. The question is whether the line should be double-tracked, or whether the single track should be electrified. Mr. Frank J. Sprague has been retained as consulting engineer.

Economizers and Steam Auxiliaries

In discussing the advisability of installing economizers in a power plant, the *Electric Railway Review* says that an important feature which is sometimes overlooked in the design of condensing plants in which economizers are not fitted, because exhaust steam from auxiliaries is available for heating the feedwater, is passing the exhaust from the auxiliaries into the low-pressure cylinder of a steam engine or one of the later stages of a steam turbine and using an economizer for heating the feedwater. The advantage of such an arrangement is especially commendable in plants equipped with condensing steam turbines. This will be clear when it is remembered that steam will generate as much power in a steam turbine when working between atmospheric pressure and the pressure in the condenser, as it will when working between 150 pounds gauge and atmospheric pressure.

The large number of exhaust steam turbine plants which have been so successfully installed in the past two or three years proves the truth of these statements. This arrangement, taken in conjunction with economizers, will show a positive saving of at least 10 to 20 per cent., depending upon the conditions.

To illustrate this case, assume a power plant of 14,000 k.w. capacity, fitted with Curtis steam turbines, water tube boilers, dry and wet vacuum pumps, circulating pumps, mechanical stokers and forced draft. All the auxiliaries are assumed to be steam driven.

Assuming a load factor 50 per cent., the output of the station would be about 7000 k.w. The steam consumption under these conditions probably would be about 19.5 pounds per kilowatt-hour hence, about 135,000 pounds of water would have to be evaporated for the main engine alone, or say 150,000 pounds, including the auxiliaries. In this case the auxiliary exhaust would be just sufficient to heat the feedwater from 80 to 205° F. Now, since a low-pressure turbine can generate a kilowatt-hour on 50 pounds of exhaust steam, the auxiliary exhaust would be sufficient to generate 300 k.w. in the main units or, in other words, produce a saving of about 4½ per cent. in the coal bill. To this must be added the saving due to the economizer alone, which amounts to 8 per cent. of the coal used if the temperature of the flue gases is reduced from 550 to 300° F. The combined saving, therefore, would be about 12.5 per cent.

As a matter of fact the actual saving would be somewhat greater than this, as the additional steam in the low-pressure stages of the turbines would materially increase their economy on light loads and thus further reduce the steam consumption. The point to be emphasized is that some engineers probably consider that the saving of 2 per cent. effected by the economizers alone is not sufficient to warrant installing them at the present money rates.

CATALOGUE REVIEW

Catalogue No. 70, issued by the Watson-Stillman Company, is, we believe, the most extensive which has yet been printed where one feature of hydraulic machine-shop tools are gathered under one cover, that is, those which are used for forcing fits or for driving broaching tools, and similar work. All of these presses are described in full dimensions, weights and prices are given, and the particular application for which each press is best adapted is stated. A curve is shown giving the pressure factor curves for forcing fits, shrinking fits and driving fits for different diameters of shaft and different allowances from which the tons of pressure required can be obtained for any particular case.

The Crane Company, of Chicago, send the July-August issue of the *Valve World*. This paper contains descriptions of pipe machines, piping specifications, tests on cranelap joints, with other information of value to the steam engineer.

Hydraulic pumps are fully described in Catalogue No. 71, lately issued by the Watson-Stillman Company. This catalogue replaces their old catalogue No. 56 relating to the same subject. A new form of large pump construction is shown, in which the accessibility of the small parts is improved while keeping at the same time the strains entirely within direct tension parts. Attention is also called to a pump which delivers 800 gallons at 30 revolutions per minute at a working pressure of 1000 pounds per square inch. The pumps are made for belt drive, for connection to electric motors, and direct-acting in the single, two, three and four plunger types. A complete list of parts is given, including all accessories.

The Cutler-Hammer Mfg. Co.(Milwaukee), makers of electric controlling devices, has just issued a booklet—pigeon-hole size—descriptive of their line of electric crane controllers. In addition to full descriptions and illustrations of five types of crane and hoist controllers, the booklet contains connection and dimension diagrams, repair part charts, prices, net weight and shipping weight of apparatus, etc. An improved form of contactor for handling heavy currents is also described.

Owing to the increase in the foreign business with Spanish-speaking countries, the Triumph Electric Company issue a special bulletin in Spanish, covering their line of steel frame generators and motors. The motors are shown completely assembled, with one end bracket removed, and the end bracket and armature are shown separately. Among the applications given is that of a direct-connected generator, a motor-operated blower, also planers and drill presses. Outlined dimensions and diagrams of connection are given in full.

Just what can happen when a steam main bursts or a fitting on the line breaks, or one boiler of a battery gives way, is vividly told in a newly-issued pamphlet describing the Lagonda Automatic Boiler Cut-off Valve. The pamphlet also explains the dangers from ammonia explosions and the way in which the Cut-Off Valve may be used to stop the flow before enough of the ammonia gets out to do any harm. A number of interesting tests are given to show the certainty with which this type of automatic valve does the work in case of accident. The valve is illustrated in detail and its action explained. This pamphlet may be had free by writing to the Lagonda Mfg. Co., Springfield, Ohio.

The "Kewanee" flange union is ably described in a four-page folder sent by the Western Tube Company; illustrations of sections through the union are given both for a properly made joint and for an improperly made joint, showing that this type of union is effected even when the pipe is not installed in perfect alignment.

Bulletins Nos. 1 to 6, inclusive, have been received from the Tacony Iron Company. In these are shown the Tacony Turbine Pump, a number of which are direct connected to electric motors. Both horizontal and vertical types of pumps are shown, and the performance is given in terms of gallons per minute with different static heads.

The General Electric Company send one of the most complete catalogues that has been received to date, which includes arc lamps for direct- and alternating-current circuits, both multiple and series, with dimensions and illustrations of glassware and accessories, transformers and panels for controlling the series alternating-current, also recording watt meters for two and three wire direct current, and for street-car service, the house meters being furnished with prepayment device, when desired. The well-known Thomson high torque induction meter, combined with the prepayment device, and with separate prepayment device, is shown, likewise, the test induction meter, and meters for polyphase circuits, indicating ammeters, volt meters and watt meters, are shown combined with complete cuts of many sizes of scales followed by lists of circuit breakers and other switchboard apparatus, transformers for single and three-phase circuits for subway service, and their accessories, feeder regulators, tirrill regulators, mercury arc rectifiers, chock coils and protective apparatus, fan motors and small power motors, with applications to sewing machines and other small work. Other details are fuses and fuse boxes and blocks, panel boards, lamp sockets and receptacles, switches, etc.

Thomson Polyphase Induction Watt Meters are made for the specific purpose of measuring energy in any two-phase, three-phase or monocyclic circuit, and consists of two single-phase motor elements, each acting upon its own disk, with both disks mounted upon a single shaft actuating the register. The meters may be applied to a circuit carrying a mixed load of lamps, motors or other devices, and record accurately, irrespective of load conditions.

Bulletin No. 4527, issued by the General Electric Company, Schenectady, N. Y., describes the latest form of these meters, which are made in three types; one for house service with metal cover, and two for switchboard use, one having a metal cover and the other a glass cover. The Bulletin gives catalogue numbers and capacities, etc., of the various sizes, and a large number of connection diagrams showing the method of installation on different classes of circuits.

Gisholt lathes are thoroughly described in a catalogue recently sent out by the Gisholt Machine Company. Their line includes lathes, boring mills and tool grinders, several applications being shown, the machines being described in full.

A novelty advertising and premium paper. One of the most novel and interesting publications that comes to our exchange table is *The Novelty News*, of Chicago, a business man's magazine handsomely illustrated, covering the field of novelty and specialty advertising, premium methods, souvenirs, emblems, post cards and advertising goods generally. It contains sixty large pages and is full of new ideas from cover to cover. It's \$1 a year.

TRADE NEWS

The Utah Copper Co. has installed in the Garfield Plant, Garfield, Utah, two Northern Cranes, one of 15 tons capacity, 3-motor electric type, 40-foot span, and one of 6 tons capacity, hand type.

Dodge & Day, engineers and constructors, of Philadelphia, have submitted a betterment report covering the entire factory of Fayette R. Plumb, Inc., of Frankford, Pa., and are now engaged in making extensive alterations to the forge shops. When this work is finished other departments will be taken up and ultimately the entire plant will be remodeled.

The Standard Underground Cable Company having been obliged for the past year to maintain Pacific Coast headquarters in Oakland instead of San Francisco have now permanently relocated at 511-512-513 and 514 Shreve Building, San Francisco, Cal., A. B. Saurman continuing as Pacific Coast manager. Their new Oakland factory is four times as large as the old factory, which was destroyed by fire shortly after the earthquake of last year. The new factory is as nearly fireproof as possible. It is equipped with new up-to-date machinery for the manufacture on short notice of insulated wires and cables, for practically any service. It is also equipped with complete warehouse facilities for handling the products of their Eastern factories and carried in stock for coast delivery.

The firm of B. C. & Wm. B. Jackson have removed their Western office from Madison, Wis., to the Commercial National Bank Building, Chicago, Ill., and that they will open an Eastern office in Boston during the month of September. Mr. William J. Crumpton will be in immediate charge of their Chicago office.

McKesson & Robbins, of New York, have commissioned Dodge & Day, engineers and constructors of Philadelphia, to make the additions to their present power plant. The addition will include a new engine, generator and necessary changes to piping, wiring, etc. Messrs. Dodge & Day made a report on power requirements for this concern some time ago and the present work is the result of that report.

Mr. F. B. Maltby, who has been connected with the Panama Canal work as principal assistant engineer to Mr. J. F. Stevens, has resigned to go with Dodge & Day, engineers and constructors of Philadelphia, in the capacity of chief engineer.

Mr. Maltby is a graduate of the University of Illinois, class of 1882, and in 1907 received an honorary degree from the same institution. He has had a long experience in railroad construction work, municipal engineering and irrigation work, and been connected at various times with the Wisconsin Central, Missouri Pacific, Great Western and Illinois Central Railroads.

He has had charge, for the United States Government, of all the dredging operations in the lower Mississippi River and designed and built the lock and movable dam on the Osage River in Missouri for the government.

He has been connected with the Panama Canal for the last two and one-half years, having had charge of the construction of railroads, docks and wharves, shops and dredging. He constructed a cold storage plant, laundry and bakery in Panama.

Mr. Maltby has designed over $1,250,000 worth of dredging plant for the canal work, and the preliminary plans and construction work for the Great Galun lock and dam were done under his direction.

The Stone & Webster Engineering Corporation announce that on August 19th they will occupy their own building at 147 Milk Street, Boston, Mass., corner of Batterymarch Street.

Mr. Simon B. Storer, consulting electrical engineer, announces the opening of an office at 732 University Block, Syracuse, N. Y., in which he will specialize in power transmission, power contracts, commercial investigations and reports.

The American Railways Company, of Philadelphia, have secured property in Dayton, Ohio, and are about to build new car barns and repair shops for the People's Railway Company. Messrs. Dodge & Day, engineers and constructors of Philadelphia, have been commissioned to draw up plans for the construction of the buildings.

The Bossert Electric Construction Company have disposed of the switchboard and panel-board department of their business to the Nyelec Switchboard Company, Twenty-eighth Street and First Avenue, New York City, who have the sole right to manufacture Bossert type switches and panel-boards. The former superintendent of this department of the Bossert factory will be in charge of the work, and the Nyelec Company will be represented by the R. B. Corey Company, 39-41 Cortlandt Street, New York City, as sales agents.

The sales force of the Holophane Company has recently been augmented by Mr. Morgan P. Ellis and Mr. Harry P. Struben.

The former comes from the Electric Appliance Company of Chicago, and will travel the Northwestern States.

Mr. Struben was, until lately, connected with the engineering department of the Pennsylvania Railroad Company, with headquarters at Baltimore. He will have southwestern territory for Holophane.

The large number of gas and electrical engineers, architects and central station men who are becoming interested in illuminating engineering, and who call upon the Holophane Company for data on this science, has led to the engagement by this company of Mr. T. R. Pemberton, in the position of office salesman and demonstrator. The Holophane Company has a very complete demonstration room, in which the illumination value of its product is shown.

The Holophane Company has added to its engineering department Mr. T. W. Rolfe, engineer, and Mr. C. W. Heck, designer.

Mr. Heck resigned from the Safety Car Heating & Lighting Company to establish a department of special fixture designing for the Holophane Company, this department being necessary to take care of the growing number of large lighting installations being handled by the Holophane illuminating engineers.

The Edgecombe Company, of Cuyahoga Falls, Ohio, has taken up electrical contracting, and would like to receive late copies of catalogues of electrical supplies.

A party of distinguished German visitors inspected the Schenectady plant of the General Electric Company, and were entertained by the company officials in that city September 5th. The visitors were designated by the German Government as a commission to visit America to inspect the electric railways and high-tension transmission systems of this country and Mexico. Numbered among the party were Privy Councilor Wittfield, of the Prussian Government; Prof. Dr. W. Reichel, of the Royal Technical University, Berlin;

Director Frishmut, of the Siemens-Schukert Works; Mr. Pforr, of the A. E. G. Railway Dept.; Director A. Elfes, of the A. E. G. Brunnenstr. and Director Jordan, of the Lahmeyer Works.

The party left Europe via Geneva, on the North German Lloyd liner *Moltke*, and arrived in New York on September 3d. The work of studying the power-houses and locomotives of the New York Central lines, the Long Island Railroad, the New York, New Haven & Hartford system, and the plants of the Interborough Rapid Transit Company was happily interspersed by entertainments given by the officials of the above-mentioned plants, and by the officers of the General Electric Company.

Boston interested the distinguished visitors, especially the big Lincoln Street power-house of the elevated lines, the Curtis steam turbine equipment of the Edison Illuminating Company, the equipment and service of the Boston traction system, including the well-known East Boston tunnel under the Charles River.

C. B. Davis, general manager of the Boston office of the General Electric Company, entertained at luncheon at the Exchange Club. Those attending included General Bancroft, president of the Boston Elevated Company; Mr. Sullivan, president of the Massachusetts Street Railways; and Mr. Edgar, president of the Edison Illuminating Company.

The very successful trip was continued to Albany, where the members of the commission stopped at Hotel Ten Eyck. They reached Schenectady September 5th and were shown through the various departments of the works and entertained at the Mohawk Club. The reception committee consisted of Vice-President E. W. Rice, Jr., Vice-President J. R. Lovejoy, General Manager G. E. Emmons, General Superintendent E. B. Raymond, A. E. G. Representative Wm. S. Hulse, Asso. Mgr. Foreign Dept. M. A. Oudin, Engineer Railway Department W. B. Potter, Engineer F. & M. Dept. D. B. Rushmore, Engineer J. E. Noeggerath, Consulting Engineer Eugen Eichel.

All day the German flag floated over the works in honor of the occasion. The commissioners were amazed at the size of the works at Schenectady and the extent of the electrical operation in progress in the various shops. The huge shop No. 86, where the Curtis turbine generators are manufactured, impressed the visitors most and they spent considerable time in the galleries watching the work in progress throughout the great building. They also found much of interest in the railway department, the wire and cable shops, the power-house and the foundries.

The guests were very flattering in their criticisms of the Schenectady plant, and the General Electric machinery which they saw.

Another silent testimony of the confidence remaining in the country's continued prosperity is the large order for railway equipment just contracted for with the General Electric Company by the Utah Light and Railway Company, of Salt Lake City.

The Utah Company is planning large extensions to its present ninety miles of track and will install fifty new cars. The contract calls for fifty complete quadruple equipments consisting of 200 G. E.-80 40 horse-power motors with K-28 controllers. In addition the company has ordered 74 GE-80 motors, with extra controllers, circuit breakers, rheostats, etc., for the re-equipment of old cars.

BIG BEND WATER POWER COMPANY.

E. P. Spaulding, Vice-President and General Manager of the concern and President of the Idaho Electric Railroad, which purposes building a line from Kingston to Murray, Ida., 33 miles, and J. S. McKenna, consulting engineer, appeared before the city council of Spokane, Sept. 3d, and submitted a petition for a fifty-year franchise to lay conduits and string light and power wires for commercial purposes in Spokane. The measure provides that the company shall build a power plant 28 miles down the Spokane River and have it in operation in three years. It is estimated that 20,000 net horse-power can be developed. It is purposed to operate 132 miles of electric railroad and light the city of Spokane, also furnish power to manufacturing plants. The company offers to deposit $10,000 as a guarantee, and pay the city $3000 a year until the net earnings shall give an amount equal to 5 per cent., which will then be paid on the earnings. B. F. O'Neill, a banker at Wallace, Ida., is president of the two companies.

Mr. Spaulding announces that the plant will cost $2,000,000. The dam will be 100 feet high and 489 feet wide, 130 feet at the bottom and 30 feet at the apex. The power-house will occupy the middle of the dam and be over the channel of the river. Its size is to be 66 by 184 feet, with walls 38 feet high and 18 inches thick, the cost being placed at $400,000. There will be seven 10-foot steel conduits leading through the dam-wall to seven pairs of turbines. The dam will raise the river for a distance of 14 miles, creating a reservoir and giving an area of 12,000,000 cubic feet of water above the dam. R. C. Lowry, of Seattle, is engineer for the company, and J. E. Ross, of Seattle, is electrical engineer.

WASHINGTON WATER-POWER COMPANY

W. A. White, of New York, who is heavily interested in this company, announces that a power transmission line of 90 miles length will be built into the Big Bend country, west of Spokane. The power is to be used for lighting towns and operating manufacturing plants and mills at Davenport, Ritzville, Reardan, Harrington, Sprague and Paha. He said his company has no plans for additional city or suburban lines, adding: "As the city grows we shall put in heavier rails and increase our equipment. Regarding the work we have under way, we have been handicapped by reason of the scarcity of labor. We expect to have our new power transmission line completed from Post Falls to the Cœur d'Alene mining district within two months. This will greatly facilitate the transmission of power to the lead mines, and it will give us a double line. The capacity will also be doubled. If necessary, our new steam auxiliary plant could be placed in commission at once. The plant is capable of developing 3000 horse-power. Next year we expect to add at least 2000 more horse-power to the plant."

SPOKANE AND INLAND EMPIRE SYSTEM.

Postal service has been installed on the Spokane-Cœur d'Alene branch, 34 miles, making two trips a day. This is the only railway postal service on an interurban electric railway in the Pacific Northwest and it is probably the first to be established in the country carrying United States mail matter distributed on the car for points beyond the termini of the line. The mail-car is fitted in the same manner as the postal cars on the transcontinental lines, with sack racks and pigeonholes for distribution of the mail. Mail matter is received and discharged at stations along the line where the car stops.

SPOKANE TRACTION COMPANY.

Clyde M. Graves, general manager, says that when the work of double-tracking on North Washington Street is completed, a 15-minute service will be put into operation between the northern city limits and Union Park, making it the longest line in Spokane.

Plans for building a $10,000,000 electric plant at 201st Street and Hudson River have been abandoned for a while by the New York Edison Company on account of the present money stringency. The new plant was to have supplemented the several other large plants already operated by the company in New York City.

Within the last year the company has increased its horse-power by 40,000, bringing the total up to 333,000. With this it operates 5,000,000 lamps. It was stated last night that the new plant at 40th Street and the East River, which was put in operation a year ago, will meet the increased needs of the company's business for the coming four years.

—From the *New York Times*.

The United States Circuit Court for the District of New Jersey filed an opinion a few days ago in a suit against the Prudential Insurance Company of America, on Nolan patent No. 582,481, granted May 11, 1897.

This opinion is the outcome, after the hearing of testimony of both sides and argument at final hearing, of a suit brought by the Westinghouse Company against the Prudential Company, charging the latter with infringement of Nolan patent No. 582,481 in the generator manufactured by the Bullock Electric Mfg. Company of Cincinnati, O.

In the United States Circuit Court for the Northern District of New York, Judge Ray handed down an opinion in the case of the General Electric Company *vs.* Wilbur F. Corliss, *et al.*, trading under the name of Corliss-Coon & Co. upon Eickemeyer patent No. 667,308, granted June 25, 1901.

In the suit of the Westinghouse Electric & Mfg. Company *vs.* Wagner Electric Mfg. Company, of St. Louis, Mo., on Westinghouse oil-cooled transformer Patent No. 366,362, the Master has awarded damages to the Westinghouse Company amounting to $132,433.35.

A preliminary injunction was issued on July 15th by the United States Circuit Court for the Southern District of New York in the case of the Westinghouse Electric & Mfg. Company *vs.* the Wagner Electric Mfg. Company for infringement of Stanley Patent No. 460,809, granted March 1, 1892. Under this decision the Wagner Electric Mfg. Company, of St. Louis, Mo., is forbidden to make, use or sell self-regulating transformers, which infringe this patent, anywhere in the United States.

Electrical Show at Madison Square Garden, New York City

COVERING a field in breadth never before attempted, the Electrical Show at Madison Square Garden takes place Sept. 30th to Oct. 9th. Plans are now formed for an elaborateness in the electrical decorations of this famous old show place by the big firms that never has been equaled, and this wealth of incandescence will represent a large sum of money. Every big firm in America is interested, and principal among the exhibitors are: General Electric, New York Edison Company, Electrical Testing Laboratories, Driver-Harris Wire Co., Safety Car Heating Co., Brooklyn Edison Co., Lord Electric Co., Standard Roller Bearing Co., Mogul Paint Co., Monatan Construction Company and others. Among the exhibits will be every invention or device used in a commercial or domestic way.

Each of the firms exhibiting will vie with the others in producing an attractive and interesting exhibit, and it will be an opportunity of a lifetime for out-of-town merchants to see everything in the electrical world in one visit. The Eastern Cahill Telharmonic Co. will fit up the Garden with their wires and give to the visiting public electric music that more than realizes the romancer Edward Bellamy's dream in "Looking Backward," written nearly twenty years ago. Another marvel will be the Photophone, with its vibratory phenomenon. By attaching this instrument to any telephone you can see the person speaking on the other end of the wire, no matter if it be over the local or long-distance telephone, as distinctly as if face to face. A demonstration of the efficacy of a recently invented burglar alarm will be given by a real live crook from Sing Sing, now reformed. Other electrical shows have been given before, but never of the bigness of the present one. The names of the directors interested give every assurance of completeness in this great educational affair. They are: Geo. F. Parker, President; Walter Neumuller, Treasurer; Dudley Farrand, General Manager Public Service Corporation and President National Electric Light Association; Arthur Williams, General Inspector New York Edison Co.; W. W. Freeman, Vice-President Brooklyn Edison Company; James R. Strong, President Tucker Electric Co., President National Contractors' Association; James C. Young, Secretary of Madison Square Garden.

Clippings from Daily Consular and Trade Reports

Tenders are invited by the Commonwealth of Australia until January 8, 1908, for the supply and delivery of one common battery switchboard and 3000 subscribers' telephones. Full particulars, specifications, bid forms, etc., may be obtained from the office of the Postmaster-General, Melbourne, Australia, or the Commonwealth Offices, 72 Victoria Street, S. W., London, England.

A concession has been granted in the Levant for the operation of a street railway line, the construction of which will require rails, fish plates, bolts and nuts, sleepers, passenger cars, freight cars, etc. American manufacturers should quote c. i. f. for cars complete and ironwork only.

An American consul in Latin America writes that the concession for a combined system of waterworks, drainage, electric light, and electric tramways has been transferred to a syndicate in which North Americans are interested. The development of these works will furnish a large number of opportunities for the supply of modern plumbing material, electric goods, etc.

Consul Harry L. Paddock, Amoy, China, requests American firms to forward to him their catalogues, price lists, trade literature, etc., which will be filed for reference.

Consul-General John P. Bray, of Melbourne, writes that the Government of the State of Victoria, Australia, has engaged the services of Charles H. Merz, one of the leading English consulting electrical engineers, to report on the suggested electrification of the suburban railways of the City of Melbourne. Mr. Bray states that Mr. Merz will arrive in Melbourne in November.

An American consul in Asia writes that permission for the construction of an electric railway has been granted in his district. The length of the proposed line is about 70 miles, and the estimated cost is about $700,000.

The Bureau of Manufactures is in receipt of a request from a New York business man that he be placed in communication with firms manufacturing naphtha motors with dynamo attachment for electric lighting. The apparatus is to be shipped to Russia.

Consul F. I. Bright, of Huddersfield, states that American machinery and engineering tools are popular in that part of England, the goods being obtained through importing houses in London, Liverpool and Manchester.

Two large Huddersfield engineering firms are extensive users of American tools and machinery, one of them having almost 75 per cent. of such equipment. The lines used in that city include factory machinery, machine tools, structural steel, laundry machinery and supplies, hardware and tools, wire cable and fencing, boilers, radiators, steam valves, and wooden parts of sanitary supplies. [A list of dealers in the above lines, as well as in electrical supplies, is on file in the Bureau of Manufactures.]

Tenders are invited until October 1st by the Swedish Government for three 350 kw. d. c. generators; 1 accumulator battery of 4800 ampere hours' capacity; 4 three-phase generators, each of a maximum of 11,000 kilovolt amperes; 12 transmitters, each of a maximum of 3670 kilovolt amperes, cables, switchboard, etc. Particulars may be had for 50 kroner ($13.40) by addressing the Managing Director, Royal Trollhattan Canal and Waterworks, Trollhattan, Sweden.

The Municipality of Buenos Ayres, Argentina, advertises for short-term tenders for the construction of underground electric tramways.

P. F. Bergasse, 299 Rue Paradis, Marseilles, France, writes that he desires American smelting and refining companies, and exporters of copper of all kinds, such as wires, bars, ingots and sheets, to communicate with him.

A description of the requirements for the four turbines wanted by a foreign government and announced in *Trade Opportunity*, No. 1207, published on July 16th, has been received by the Bureau of Manufactures, and will be loaned upon application from manufacturers.

The suburban authorities of London will not permit the adoption of the overhead or trolley system, but are inclined to agree to an experiment with a surface-contact system. In the new system under contemplation the electrical energy is obtained by the contact of skates fixed under the cars with studs on the surface of the road. These studs in the center of the tracks are brought into contact with cables underneath by a mechanical device operated by magnetic action. The studs are only charged with electricity when a car is actually passing over them. The principal advantage of the system from the point of view of the London tramway authorities is that the excavation required for the laying of the tracks is very much less than with the conduit, and the cost is proportionately reduced.

Under normal conditions the cost of the three systems per mile of single track, exclusive of cables and other equipment common to all, compares as follows: Underground-conduit system, $85,000; surface-contact system, $52,500; and overhead-trolley system, $49,500. Terms have been tentatively arranged with the owners of the patents by which they will make a royalty of $2,500 a mile of single track and a smaller sum per mile in the event of the system being used on a large scale.

Consul-General W. H. Michael writes as follows from Calcutta: The Punjab Government has, under the Indian Electricity Act, granted a license to the Punjab Power Association for the supply of electricity to the city, civil station, and suburbs of Lahore. In the Government order granting the license the association is stated to be represented by the following gentlemen: Maj.-Gen. Beresford Lovett, C. B., C. S. I., R. E., of Simla; Sir Thomas Highham, K. C. I. E., of Clifton, Bristol; Mr. W. R. Shaw, of Upper Norwood, London, and Prof. C. A. Carns-Wilson, of Westminster, London. The two former are retired Indian officials who had long service in this country.

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Interior Wiring

ELECTRICIANS familiar with modern methods of interior wiring frequently comment on the crude material and workmanship found in old buildings. Numerous instances are encountered where slow-burning weatherproof wire, or fire-proof wire, as it was called at one time, has been fished through partition walls without protection from contact with woodwork; and often with the insulation, better termed the covering, damaged, leaving the copper wire bare in places. Other instances are encountered where wire has been pulled into ordinary gas pipe with cast-iron elbow fittings, and the wire on removal has been bare in places, showing the insulation scraped from the wire by the sharp corners of the elbow. Snap switches designed to carry 10 amperes have been made to carry 20 to 30 amperes with excessive heating at the contacts. In one particularly bad case it was necessary to keep the door of a panel box open because the switches would otherwise have fused so that they could not be operated. Frequently the slate bases of knife switches were defective; even as now made they are found faulty—one test made at a recent date proved the resistance between blades of several knife switches mounted on plain slate bases to be below 100 ohms, and in one instance it was as low as 30 ohms. These facts make it apparent that definite rules for governing the wiring of buildings must be enforced.

A number of associations have prepared a set of rules and regulations for the guidance of inspectors in the employ of The National Board of Fire Underwriters. With some slight additions, these rules and regulations have been adopted by The New York Board of Fire Underwriters. All wiring and appurtenances should conform with the rules and regulations in force even though the insurance rates are not affected thereby, and where there is no inflammable material. The rules have been prepared for the betterment of all electric systems.

Engine houses, round houses and boiler plants, constitute a class of buildings not subject to an increase of fire risk from defective electric wiring since they are constructed of brick and metal and contain no inflammable material, but they present unusual difficulties in maintaining the electric wiring in an operative condition.

Open wiring in such buildings is exposed to the gases given off by burning coal and will last perhaps one year before falling to pieces. After this time, the wire can be readily broken or may break from its own weight. The gases given off by burning coal are extremely injurious to copper since the coal frequently contains sulphur and moisture. The sulphur burns to form sulphur dioxide and the moisture appears in the gases as steam. Sulphur dioxide combines with steam to form sulphurous acid, which attacks copper more viciously than does sulphuric acid. Sulphuric acid does not readily attack copper unless heated to a high temperature, this fact having been pointed out by chemists to show that the sulphur gases should not affect wiring to a great extent. They overlook the fact that sulphurous acid and not sulphuric acid is the active agent.

Wiring adjacent to burning coal must be protected. The best method of protecting the wire is to use lead-covered wire run in conduit and to bury the conduit in concrete. All switches and lighting fixtures should be of the marine type, absolutely moisture-proof, with all exposed metal heavily painted. Sockets should be enclosed in vapor-tight globes, as steam will condense on ordinary open sockets and short-circuit the contacts at the lamp.

A peculiar trouble is encountered with iron conduit in that moisture will appear inside of the conduit even though it be absolutely tight. This moisture is generally attributed to condensation though it will be found where the conduit is absolutely tight and no moist vapor can find entrance.

The reason for the existence of water inside of tight conduit is not satisfactorily explained by saying "it is condensation." It must come from the decomposition of the insulation on the wire.

In fact, there is no other possible source for this moisture. The conduit is tight and the moisture is found when the conduit is opened. Since the only matter present inside the pipe is the copper wire and its insulation, the moisture must come from the insulation.

Granting that this moisture is from the insulation, the question arises whether it is advisable to drain off this moisture, as by so doing the insulation may deteriorate more rapidly than it would if the moisture were left in the conduit. The insulation becomes hard and brittle with time when the moisture is drained off. Results are not available to show the effect obtained when the moisture is left in the conduit, though it would probably cause trouble at fixtures. Even the lead covering over the insulation does not prevent this appearance of moisture, which fact might be stated to prove that the moisture is condensed from the surrounding air. The theory of dissociation of matter permits of explaining this phenomenon with the supposition that chemical combination does not take place until the hydrogen ion has dissociated from the insulation, passed through the lead and come into contact with the outside air.

It is the custom to drill holes in conduit at its lowest points in order to permit the escape of water.

Another problem is the selection of a finish for iron conduit. Conduit either galvanized, black enameled or painted may be had in the open market. Tests have been made to determine which finish affords the most efficient protection, though the results secured have not been satisfactory. Some tests indicate one finish to be most durable, while tests made with other conditions show some other finish to give the best results. Obviously a finish should be selected that gives the best results with the particular conditions to be encountered in actual service.

Unprotected wrought-iron pipe or conduit will remain in good condition for several years when buried in perfectly dry ground; where decayed vegetable matter is present the conduit will become pitted within one year. This pitting of the conduit is usually attributed to electrolysis caused by leakage current from nearby street railways. The results are the same, however, when the conduit is buried in moist ground many miles from street railways. Iron conduit buried in moist ground cannot be expected to have a life of more than two or three years. Conduit imbedded in concrete is preserved almost perfectly no matter what the finish on the conduit may be. The concrete rapidly dries so as to be a fairly efficient insulator. Any finish of conduit will last if the conduit be carried through concrete.

Apparently the rapidity of pitting of iron conduit depends on the amount of moisture and organic acids present in the ground. This is as might be expected. Local currents are set up between different substances in the iron in the same manner as observed on an unamalgamated zinc in a primary cell. Where an impurity is present, a local current is set up either with another minute impurity slightly more or less positive, or with the iron of the conduit, the direction of current depending on the substances. A small carbon particle forms the positive pole to pure iron in contact with surrounding acid or dirty water with the result that current flows from the carbon to the iron, then through the water to the carbon, this action continuing without regard to the current in a wire that might or might not be inside the conduit; and with the result of a rapid conversion of the iron to a soluble salt. A heavy coating of paint prevents this galvanic action as long as the paint is in good condition. Concrete also prevents this galvanic effect.

Conduit should be installed in buildings while in course of erection. It is as necessary to provide space for conduit as it is to provide space for other pipes. Wires are too frequently considered unimportant on account of their small size. Ordinarily, an architect will not provide space for them with the result that joists and timbers must often be cut, thus weakening the building structure. One circuit of 12 incandescents is supplied by wire run in a conduit of ½-in. nominal internal diameter, actually about ⅝-in., and of an external diameter slightly less than one inch. This size of conduit does not require a large amount of room, and space need not be provided for one or two circuits. A large building, however, requires many circuits, making it imperative to cut the supporting timbers, to run the wire exposed, or to provide a wire way. Besides preventing the contractor from excessive cutting of timbers, the wire way allows him the opportunity to make a neat, workmanlike system with provision for the extension of electricity for other purposes besides lighting, thus making the building more acceptable to the prospective tenant.

Solid iron conduit pipe with a protective covering gives efficient service. When a building is to be wired after erection some other method of protecting the wiring must be adopted. There are three systems for wiring old buildings: first, with flexible conduit; second, with wood molding, and third, by running the wire open.

Flexible conduit may be obtained of steel or of fibrous material, the selection between these two materials being largely a question of the amount of protection to be afforded from mechanical injury. The flexible steel conduit protects the wire from nails that might be driven through floors or walls.

Wood molding gives efficient protection in dry locations, but unless made to match the wood trimmings in the room does not present a better appearance than wire run open.

Open wiring when properly erected with wire run perfectly straight can be installed so that it will not be a disfigurement. A popular method at one time was to install rubber-covered wire with a slow burning, white braid; in some cases the wire was given a coating of white enamel. Wire need no longer be concealed for the purpose of improving the appearance, though it is highly desirable that it be run concealed as a protection from damage.

Another ornamental system of wiring is to run the wire in brass conduit, the conduit being polished and lacquered. This latter method, while expensive, can be made extremely attractive with the proper conditions of room decoration. Every building has particular features which best adapt it to some one of the above methods of installing exposed wiring.

Usually the term "open wiring" is taken to mean wiring with porcelain cleats, knobs and insulators. Cleats can be obtained which separate the wire ½-in. or one inch from the supporting surface, knobs support the wire ½ in. from the surface and insulators support the wire at a distance of one inch from the surface.

Wiremen frequently object to the ruling of fire underwriters' inspectors who require insulators or cleats supporting the wire one inch from the surface in damp locations. This ruling is based on observed facts. Wire insulation deteriorates so that it becomes inefficient. Where the two wires of a circuit touch the supporting surface a leakage current will flow between these wires. When this leakage current flows through wood it gradually carbonizes the wood, making it a better and better conductor, until finally the leakage current is sufficient to ignite the wood. The additional ½-in. space required in some cases lessens the probability of the wires touching the surface.

The relative merits of split and tie knobs or cleats are frequently discussed in connection with the probable leakage current across each. Split knobs permit of making a job of better appearance with less labor than tie knobs. They have, however, less leakage surface than the tie knobs, the current leaking from the wire to the retaining screw and then to the wood. Split knobs are not usually glazed at the junction of the two parts, which permits of absorbing and retaining moisture at this point.

Open wiring should be protected from abuse. Where wire is run across a room at some distance from the ceiling without a running board there is a liability of some one hanging clothes or rags over it, thus presenting an excellent opportunity for the starting of a fire. A running board is always desirable for protecting open wiring which is not run close up to the ceiling.

The subject of wire insulation at the present time is only thoroughly understood by specialists in this line. Ordinarily, the electrical engineer is satisfied with specifying a rubber insulation containing 20, 30, or perhaps 40 per cent. of new para rubber and trusting to the manufacturer to supply this percentage of para. A better procedure is to specify several makes and trade names of wire that have proven satisfactory. Tests for determining the exact percentage of para in the insulation can only be made by experts with delicate apparatus. One simple method of determining the approximate percentage of para in the insulation is to cut a portion of the insulation from the wire, and to measure the percentage increase in length to which the sample can be stretched without breaking, and the length to which it will return when released. It is important to determine the final length of this sample because this length indicates the quality to as great an extent as does the initial elasticity.

A thickness of $^1/_{64}$-in. of the insulation immediately adjacent to the metal wire is unvulcanized to minimize the chemical action between the copper and sulphur in the vulcanized insulation. The copper conductor is tinned to further minimize this action.

The unvulcanized portion of the insulation is known as the core. Several manufacturers have adopted a distinctive color for the core; in some cases they have adopted two colors to distinguish between their different grades of insulation. The better grade of insulation is in some cases designated by a white core while a red core is used to designate a poorer grade; in other cases these colors are chosen in the reverse order. A number of other manufacturers make the core and insulation of one uniform color.

The necessary thickness of insulation for low voltage service, below 600 volts, is determined by the size of wire. The insulation must be thick enough to prevent fractures developing from bends in the wire. A clause might advisably be added to specifications tabulating the maximum size of wire which may be bent to a stated radius. The reason for the added thickness of insulation for large wire and the minimum advisable radius to which large wire should be bent is due to the fact that insulation on large wire is stretched and compressed to a greater percentage of its original length than is the insulation on small wire when the wire is bent to the same radius. The insulation on large wire is necessarily thicker than that on small wire, owing to the difference in weight between large and small wire, the heavier wire requiring a stronger insulation to resist abrasion when installing.

Insulation tests are usually more severe than necessary. One test that frequently does more harm than good is the high potential break-down test so often specified. It is advisable to specify a moderate break-down test on large orders of wire as such tests will demonstrate the uniformity of the insulation, but there is absolutely no excuse for the modern tendency to specify excessive break-down tests. Moreover, the probability is that the insulation will be weakened by applying excessive tests. Manufacturers can either reject specifications calling for excessive requirements, can overlook the excessive test requirements, or can supply what is specified and charge for their product accordingly. In any case, the wire secured under unusual test requirements is no better than ordinary wire and will probably be found defective in actual service.

Another requirement usually made excessive is the insulation resistance required of wire. The manufacturer can make any grade of insulation have as high a resistance as required. All that is necessary is to dry out the insulating compound. This drying-out process, while it gives a high initial resistance, makes the insulation brittle so that it is liable to crack at bends. A moderate insulation resistance is desirable, as it is an indication of the efficiency of the insulation. Excessive test requirements of any form are not producive of goods as uniform in quality as the standard test requirements produce.

Protective braid should be tough and pliable, with threads of some length, and uniform in color, showing the impregnating compound to have entered all parts to an equal degree. The outside surface of the braid should be hard and smooth.

No difficulty is encountered in obtaining copper wire with a conductivity closely approximating 100 per cent. There are two reasons for this. One reason arises from the mode of selling bare copper wire. It is sold by weight, the weight determining the exact length; both the weight and length can be readily measured within a fraction of one per cent., thus limiting the error in either quantity well within one per cent. The other reason arises from the unit of resistance measurement being higher than is actually the case. Pure copper has less resistance than the present accepted standard.

Joints at branches in wiring when well made by experienced wiremen are effective in carrying the current, and are effectively insulated. Such joints require valuable time; it is usually cheaper and better to avoid joints at branches by extending the wire from outlet to outlet, continuing the wire in one length from the panel board to the last lamp on the circuit. The wiring is then said to be installed on the "loop" system. This system is specified and required by most engineers in charge of large work without regard to the relative positions of the outlets and the building structure. Conditions at times absolutely prevent the extension of the "loop" system to include all outlets.

The above general rules cover a few of the details related to interior wiring. The standard wiring methods and materials only are mentioned; the many types, makes and sizes of porcelains, conduit, fittings and fixtures amount to an immense number. The wiring contractor must be familiar with all of these details; he must know the best methods of doing the work; he must erect work to comply with specifications often contrary to his own judgment; he must do work not fully covered by the specifications as directed by the engineer in charge, and the completed work must be approved by the inspectors of the fire underwriters and of the municipal authority. Frequently, too, the work is allotted on the lowest proposal of many contractors, all of whom have reduced their margins of profit to small computed amounts with the expectation of getting the job. It is needless to say that such business more or less demoralizes the craft.

H. A. Sinclair, secretary and treasurer of the Tucker Electrical Construction Company, agrees in general with the principles set forth. He adds that enclosed fuses should be used more extensively than at present as they generally tend to prevent the replacing of a fuse with copper wire, though he had lately inspected the wiring equipment of a building and found nine places where enclosed fuses had been replaced with copper wire. Such a practice he designated as criminal.

Mr. J. C. Forsyth, chief inspector of the New York Board of Fire Underwriters, stated that but little printed matter had been published on the above subject.

He adds as follows: "A decent compound is little affected by the continuous presence of moisture, but the alternate presence of moisture and the drying out of insulation causes the insulation to deteriorate rapidly even when composed of the best compound.

"By decent compound I mean a compound properly vulcanized and with all sulphur eliminated after vulcanization. The sulphur when present in the compound oxidizes the copper conductors. Tinning prevents this action.

"The core of unvulcanized rubber next to the copper betters the insulation for initial tests, but soon deteriorates, pulverizing to a dry powder.

"A lead sheath, or any other covering that excludes air from the insulation, is effective in preserving the insulation in its initial condition for an indefinite period. The lead, however, may become pitted by electrolytic action, in which case it, of course, loses its value in this respect. Joints of lead-covered wire must be carefully made, every precaution being taken to prevent the entrance of moisture at the ends of the lead sheath.

"The conditions to be encountered must be considered. In engine-rooms where conduit is of necessity run close to steam pipes, rubber-covered wire is not satisfactory. Slow burning weather-proof wire gives good results in such locations. I require slow burning weather-proof wire in iron conduit pipe where the conduit is installed in dry and hot locations.

"I do not consider the percentage of fresh para contained in an insulating compound as important as some seem to think it. In some cases a high percentage of para is important, though my experience shows that a low percentage of para gives good results with average conditions. Correct vulcanizing of a compound is of more importance than the percentage of para used in making the compound.

"Water will appear in conduit. This is usually attributed to condensation of moisture contained in the air in the conduit. Part of this moisture may come from decomposition of insulation; almost all substances give off moisture when heated."

Mr. Forsyth then unwrapped a short section of iron pipe, which had been cut from a length to show the effects of a break-down, due to water of condensation. The length of run was 150 ft., size of pipe three inches, and there were two 500.000 c. m. stranded cables in the pipe. The length where the break-down had occurred was in the lowest portion of the run. One cable had been fused apart and numerous large holes in the pipe were evidence of the destructive effect of the burn-out.

"I require all conduit to be tapped at the lowest points to drain off moisture.

"The principle fire hazard comes from weak, unmechanical switches, cut-outs and other devices. These devices heat at the contact and cause the major portion of the fires traced to defects in electric construction. A strong construction is essential. Switches, cut-outs and other electric devices should withstand normal service indefinitely."

The Electrical Show, Madison Square Garden

THE Madison Square Garden Electrical Show is over for the year 1907. In every way the show has been a complete success, and its energetic management has demonstrated again that an electrical fair is a highly beneficial thing to the whole fraternity of dealers, jobbers and manufacturers if rightly conducted.

The three illuminating companies in Metropolitan New York joined hands, and their united efforts produced such a show of enthusiasm, good feeling among exhibitors and large attendance by the public as has not been reached since the initial Madison Square Exhibition in 1896, and the opening show of Chicago in 1905.

The usual small booth littered with its exhibitor's line of goods was conspicuous in its rarity. Most of the smaller booths were tastefully decorated, the exhibitor seizing upon some decorative feature of his product for its better display. Unlike preceding electrical shows in the Garden, there were no fake exhibitors. The management is to be commended for its courage in refusing to allow the small concessionnaire to prey off the visiting public. Heretofore the temptation to make a few extra dollars off this class has resulted in a succession of deteriorating shows from which the business-seeking trade exhibitor has shrunk.

The Electrical Testing Laboratories occupied three booths, making an elaborate display calculated to impress the engineer with its facilities for test work. One of the novel things seen in its booth was a stroboscopic view of an alternating-current arc magnified about 20 diameters, so as to be visible to a visitor in the aisle outside the booth. An oscillograph in continuous operation showed the wave forms of a condenser current, and a voltage curve, together with the generator-current curve, disclosing in a beautiful manner the irregularities of the commutation.

The Brooklyn Edison Company showed a model apartment, utilizing every possible household device of an electrical kind. The arrangement of lights was planned by Van Rensaeller Lansingh, and the inspection of this apartment ought to have been instructive to central-station solicitors in the smaller cities near New York.

The United Electric Light & Power Company made, perhaps, the most elaborate display seen. Its alternating-current sign of large size overhung their space, carrying at one end a full-size leaf of the Gold Seal sign, so familiar to Broadway.

The New York Edison Company built a splendid octagon pavilion in the center of its extra large booth, and arranged more than a score of power and utility applications about its booth, each in charge of a demonstrator. This was a novel departure by an exhibiting central station from the usual display work and was calculated to familiarize power users with the possibilities of the electric motor, as perhaps could not be done in any other way. Its uniqueness is very likely to associate the Edison Company with electric-motor work in the minds of the public.

Electric lighting has come to be so common a feature of such displays that we may presently expect central stations to pay little or no attention to this end of the business at our electrical shows, leaving it to the manufacturers to educate engineers. The public does not care whether it gets tantalum, carbon or tungsten. What it wants is agreeable light at a reasonable cost.

The unusual attendance of visiting engineers at this exhibition led to much actual selling on the part of the exhibitors. Mr. James Olsen, of the Habirshaw Company, made a statement at the exhibit that he was more than pleased with the whole affair, and had gotten in touch with a number of engineering customers whom he had not seen for years. Another manufacturer stated that he had taken orders for several thousand dollars' worth of business and had obtained a very large number of leads for new business. One of the sign manufacturers was taking orders at the rate of 15 to 20 a day, chiefly from merchants in the city. Two hundred and fifty prospects and an average of fifteen contracts a day was the visible result of the activity of one of the exhibiting central-station companies.

The exhibit covered the entire ground floor of the Garden, occupying a total floor space of 16,800 square feet. It is understood that all of this floor space has been contracted for next year, and a number of the exhibitors have signified their intention of placing heavy machinery in the basement of the Garden. The first balcony of the Garden will undoubtedly be required for exhibitors at the coming 1908 electrical exhibition.

The Electric Illumination and Wiring of the Singer Building

THE new Singer Building, when completed, will be 42 stories high, the tallest office building in the world, and is now a distinctive landmark in the sky-line of lower New York. Naturally a building of this size presents special problems in installing the electric equipment, not only on account of the size of the building, but also on account of its height. Special lighting features must be supplied for the purpose of illuminating the exterior of the tower at night.

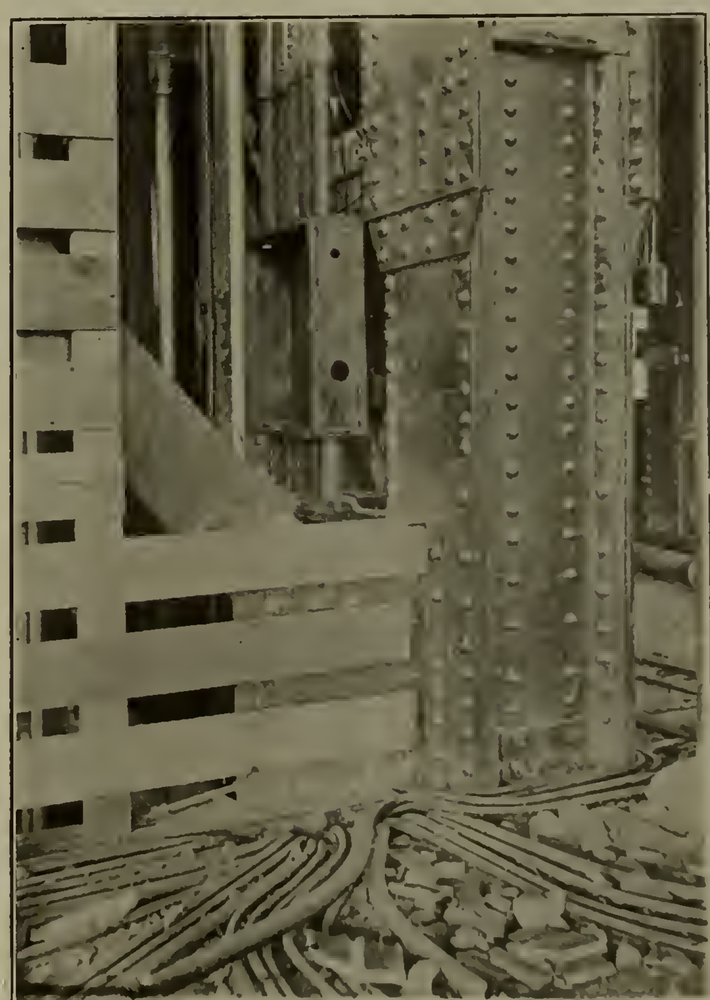
The electrical work is being installed by the M. B. Foster Company, under the direction of Ernest Flagg, architect.

The details of the plant were worked out by the engineering department of Mr. Flagg's office, Mr. O. F. Semsch, chief engineer, and by the owner's consulting engineer, Mr. Chas. G. Armstrong. We are indebted to Mr. Semsch for the information below.

All motor wiring is to be two-wire 220 volts. Main feeders, switchboard, panel boards, switches, etc., for light wiring will be arranged on the three-wire convertible system. Distributing circuits and all switches are to be designed for 220 volts, it being the intention to operate the lighting system for the present at 220 volts.

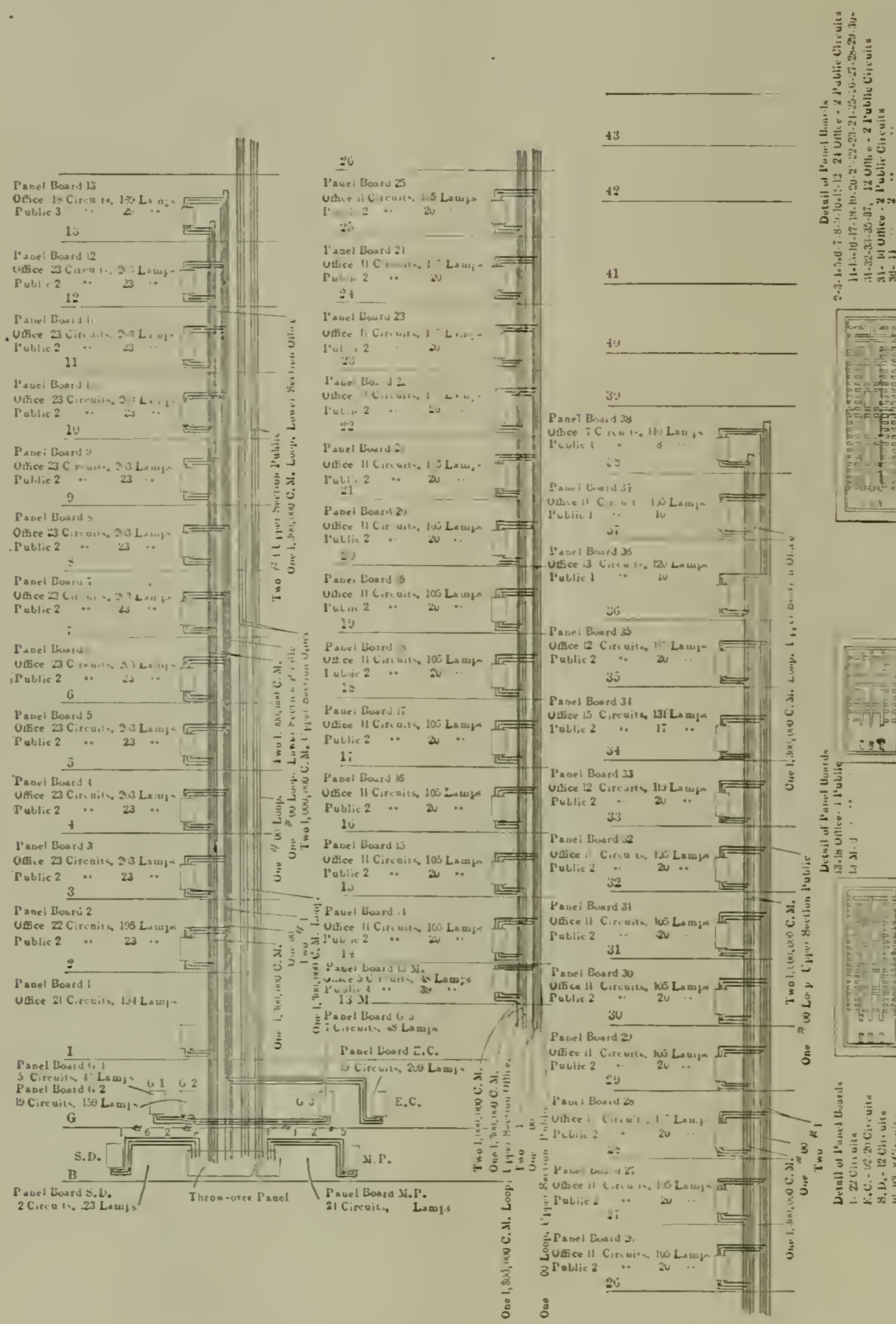
Starting from the generators, the wiring will consist of leads for connecting five generators to the switchboard, including equalizer connections. These cables are to be run in iron conduit which will be buried in the concrete floor; they are to be lead covered and paper insulated, as made by the Standard Underground Cable Company. Paper insulation is to be $^{3}/_{32}$-in. thick and the lead sheaths will be $^{1}/_{8}$-in. thick for 1,500,000 c. m. cable, the thickness of the lead sheath being reduced to $^{7}/_{64}$-in. on 800,000 c. m. cable. Cast-brass end bells, each with hard rubber cap, are to be supplied at the ends of each cable, each end bell being filled with No. 1 Ozite compound.

The switchboard will consist of polished white marble panels two inches thick bolted to a frame of structural iron which will be anchored to the floor and braced from the wall. Suitable packing will be supplied between the marble and the frame to prevent breakage. All exposed parts of the frame are to have electro-bronze finish and unexposed parts are to be painted. The space beneath the board will be filled with copper netting of flat wire and end spaces will have copper netting doors with strong hinges and fastenings. The instruments sup-



THE CONDUIT IS FOR CIRCUITS FOR THE FLOOR BELOW.

plied on the switchboard will consist of four 1250-amp. double-pole circuit-breakers operating between 900 and 1800 amp. and one 800-amp. double-pole circuit-breaker operating between 600 and 1200 amp. Also four 1800-amp. quick-break, double-throw fuseless switches and one 1200-amp. quick-break, double-throw fuseless



RISER DIAGRAM—NEW SINGER BUILDING.

switch and five field rheostat switches. There are to be five station-type ammeters, four of which will have a maximum scale reading of 2000 amp. and one with a maximum reading of 1500 amp.; also five station-type voltmeters reading from zero to 300 volts. One voltmeter and switch will be installed with contacts for each set of bus-bars and for ground, and two summation ammeters will be connected to the two sets of bus-bars on shunt circuits each for 3500 amp.

All of the above instruments will be of the station type and guaranteed correct within one per cent. of capacity under operating conditions. They will have dust-proof, soft-iron cases which will be heavily copper-plated front and back. The light and power bus-bars will be connected by one triple-pole, single-throw, double-break switch of 2000-amp. capacity, one pole being for the equalizer bus.

All circuit-breakers are to be I. T. E., laminated, dublarm type with independent operating arms for 250 volts with both overload and shunt-trip coils, finished in the standard manner and mounted on polished slate with rear connections. Three push-buttons are to be connected to the shunt trip-coil of each circuit-breaker for remote control, these push-buttons to be located as follows:

One on each generator.
One group of five central in the engine-room.
One group of five in the chief engineer's office.

Lamps will be installed on the switchboard for illuminating the instruments.

The schedule of feeder circuit-breakers is as follows:

1000 amp. lower office Singer addition.
1000 amp. upper office Singer addition.
600 amp. office of the Singer building.
600 amp. office of the Bourne building.
600 amp. office of the Bourne addition.
400 amp. outside lighting Singer addition.
300 amp. search-lights Singer addition.
200 amp. lower public space Singer addition.
200 amp. upper public space Singer addition.
100 amp. safe deposit vault.
100 amp. mechanical plant.
100 amp. public space in the Singer building.
100 amp. public space in the Bourne building.
100 amp. public space in the Bourne addition.
1000 amp. elevators Nos. 1, 2, 3 and 4 Singer addition.
1000 amp. elevators Nos. 5, 6, 7, 8 and 9 Singer addition.
1000 amp. elevators Nos. 10, 11 and 12 Singer building.
1000 amp. elevators Nos. 13, 14, 15 and 16 Bourne building.
200 amp. four basement fans.
100 amp. three sump pumps, two iced-water pumps, motor generators, paper press, and small fan.
100 amp. carpenter shop.
100 amp. repair shop.
50 amp. fan on the thirty-ninth floor of Singer addition.
50 amp. fan on the roof of Singer building.
50 amp. fan on the roof of the Bourne building.
50 amp. vacuum ash handling apparatus in the basement.
50 amp. pneumatic service in the basement.
— amp. spare.

The Bourne building and Bourne addition are adjacent to the Singer building and Singer addition.

All of the above circuit-breakers will be two-pole switch-type for 250 volts, those for lighting feeders being arranged for a third pole in the future.

All switches are to be constructed of pure rolled copper with a conductivity of 98 per cent. and a cross section allowing for 800 amp. per square inch; contact surfaces being of a size to present a contact surface equivalent to 50 amp. per square inch. All connections on the back of the switchboard are to be made with flat bars.

There are to be two sets of generator bus-bars, one for supplying light and one for power; these to consist of positive, negative and equalizer busses with provision for a neutral to be installed at some future time.

All generator switches are to be connected to the two sets of bus-bars, and one side of each break-down switch is to be connected to the proper bars.

The break-down switches are for the purpose of supplying the service from the Edison system, if necessary.

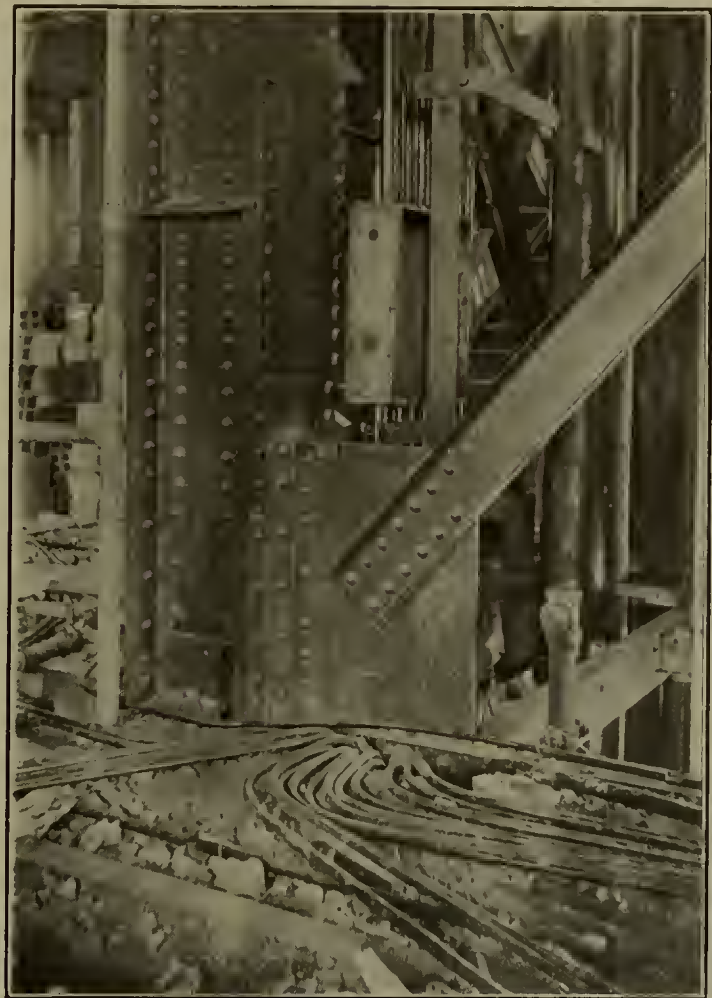
Two sets of Edison service bus-bars will be installed, one set for lighting and one set for power, with provision for a future neutral on the lighting set. One side of the break-down switches will be connected to these bus-bars. Provisions will be made for connecting the Edison service to these bus-bars, dividing the bars to suit the size of the several feeders.

Each group of circuit-breakers is to be connected to one section of the above bus-bar sections and each section will be connected to its proper break-down switch, provision being made for the addition of a future neutral on all lighting sets. The bus-bars are to be of a size which will allow of not over 800 amp. per square inch and will allow of a contact surface of 50 amp. per square inch. They are to be made of thin copper strap with air-spaces between, only pure rolled copper with a conductivity of 98 per cent. being allowable.

The switchboard is to be arranged so that the system can be changed to a three-wire system with the least possible work. The lighting of the Singer, Bourne and Bourne addition buildings is to be balanced on the three bus-bars by floors or feeders when the system is changed. All bare copper on the switchboard is to be spaced for 240 volts. All switches and circuit-breakers are to have spring washers at the hinge joint. An engraved copper name-plate will be mounted at each switch and circuit-breaker to designate the circuit controlled. The following integrating wattmeters will be erected near the back of the following panel boards; the wattmeters are of the Thomson type:

Two 1000 amp. for the office lights in Singer addition.
Three 600 amp. for the office lights in the Singer building, Bourne building and Bourne addition.
One 400 amp. for outside lights.
One 300 amp. for search-lights.
Two 200 amp. for public lights Singer addition.
Two 100 amp. for safe deposit vault and mechanical plant.
Three 100 amp. for public lights in the Singer building, Bourne building and Bourne addition.
One 50 amp. for exhaust fan on the thirty-ninth floor.

A marbleized slate panel will be mounted near the motors with the following integrating wattmeters:



JUNCTION BOX AND RISERS.

Eight 250 amp. for elevators.
One 150 amp. for shuttle elevator.
One 75 amp. for the 120 in. pressure fan.
One 75 amp. for the 80 in. pressure fan.
One 50 amp. for the iced water circulating pumps.

All of the above wattmeters are to be 240 volts two-wire.

The Liberty Street Edison service is to be extended in the Singer and Bourne buildings to the switchboard, where it will be connected to the proper throw-over switch. The Broadway Edison service will also be carried to the switchboard and connected to the proper switches. The size of these feeders will be as follows for each leg.

BROADWAY.

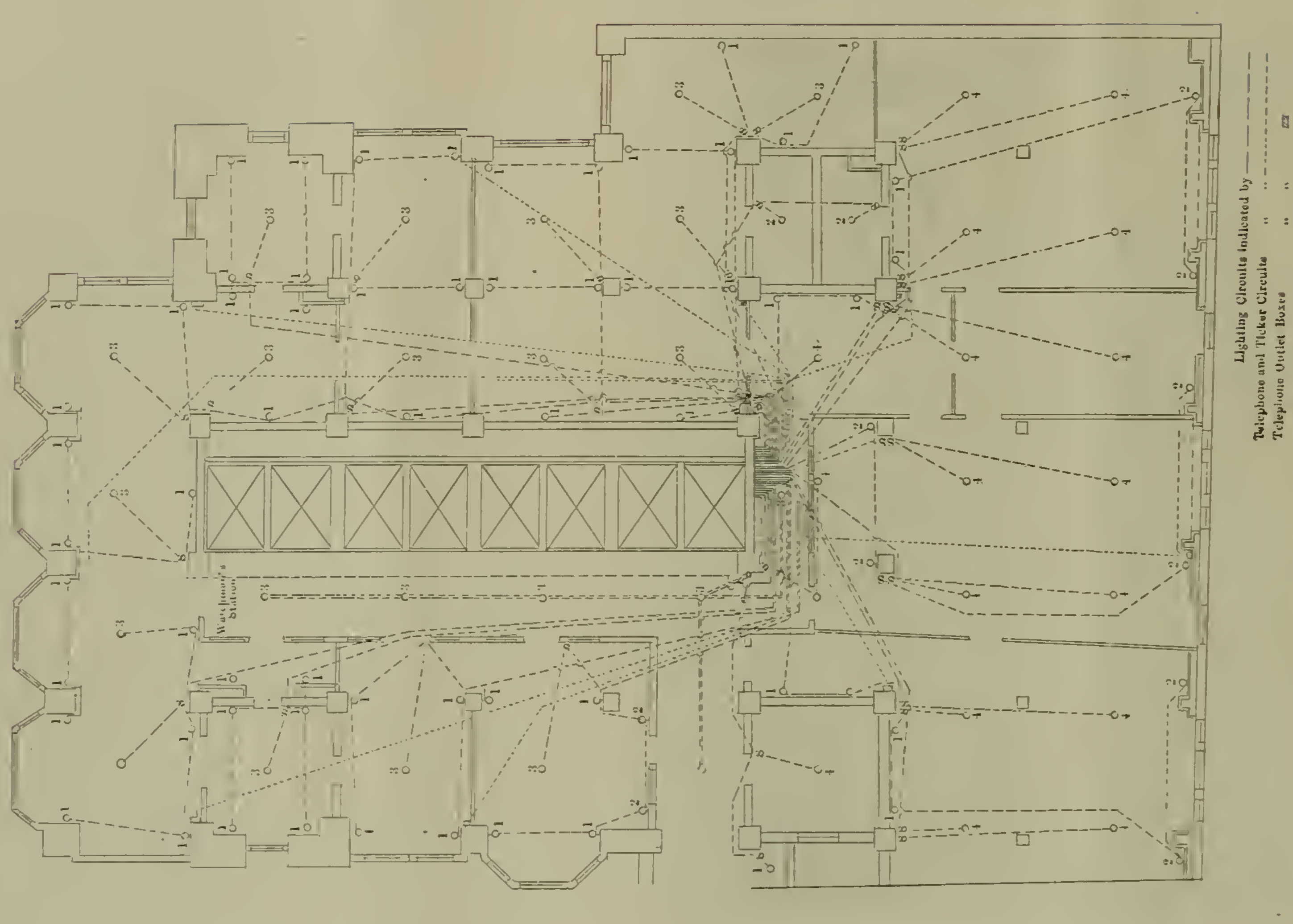
Two 1,500,000 c. m. cable for Singer addition lights.
Two 1,500,000 c. m. cable for Singer addition power.

LIBERTY STREET.

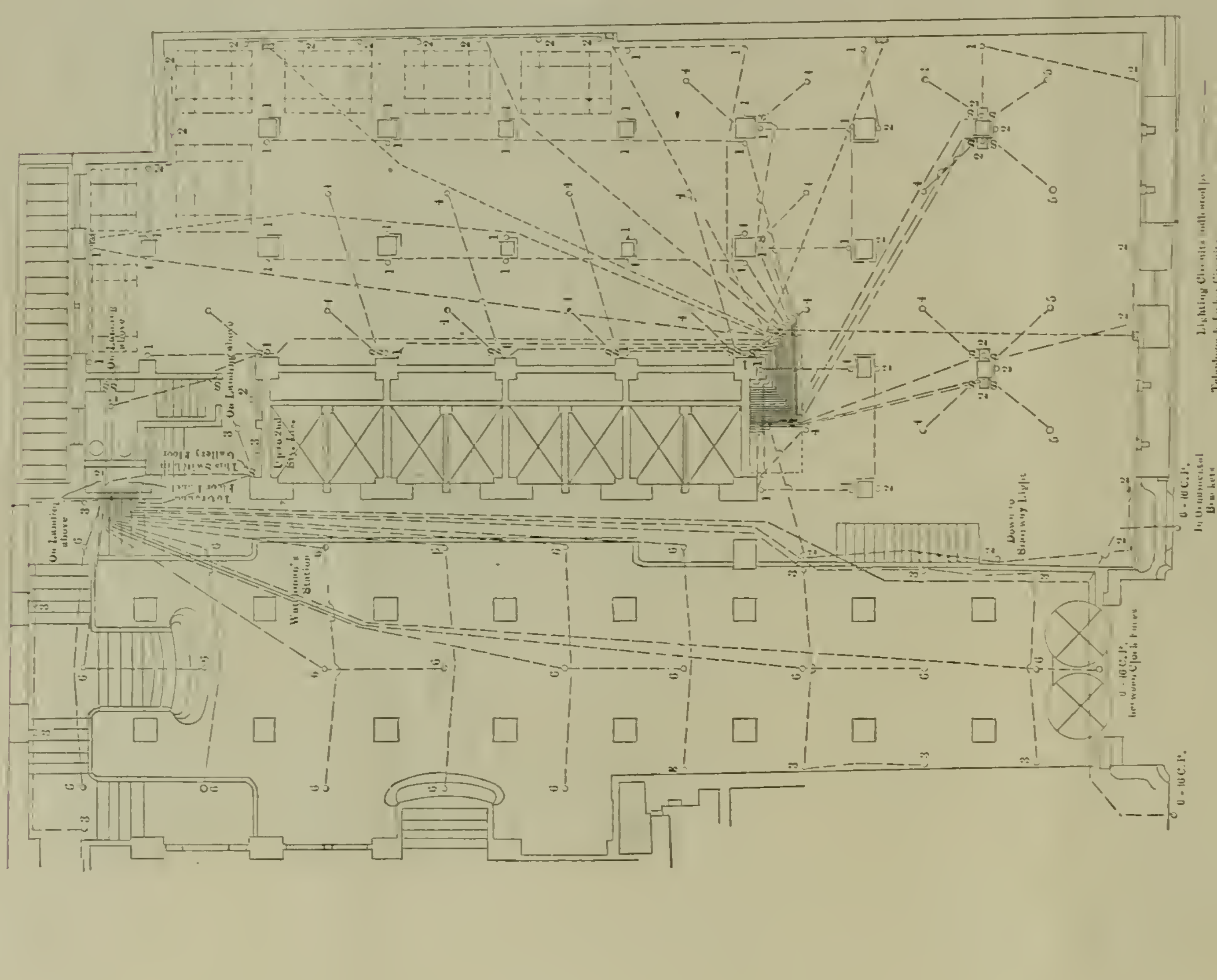
One 800,000 c. m. cable for Singer building lights.
One 800,000 c. m. cable for Bourne building lights.
One 800,000 c. m. cable for Bourne addition lights.
One 400,000 c. m. cable for Singer building power.
One 1,600,000 c. m. cable for Bourne building power.

Feeders are to be run from the switchboard to the panel boards through the basement to and up the shaft back of the elevator. Those for the lower part of the building are to be run behind elevator No. 8, and those for the tower behind elevator No. 4. All lighting feeders are to be installed on the loop system and the three-wire convertible system. All office lights below the thirteenth floor mezzanine are supplied by one feeder extending from the switchboard in the basement. The public lights in this section are to be on another separate feeder. Similarly, all office lights above the thirteenth floor mezzanine are to be on one feeder and the public lights on another. Feeders to safe-deposit vault panel and to mechanical plant panel are separate and therefore

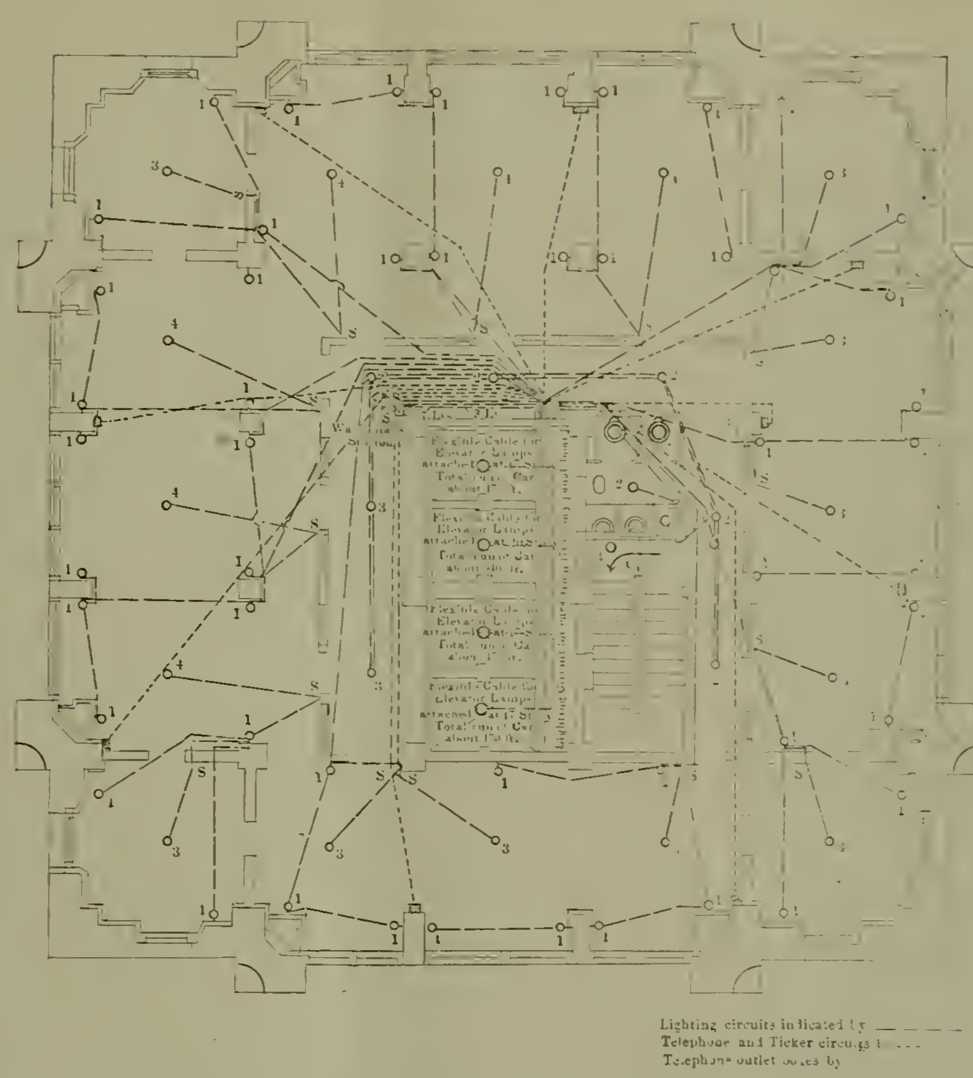
CEILING OUTLETS.



ELECTRICAL PLAN—TWELFTH FLOOR OF THE NEW SINGER BUILDING.
THE THIRD TO NINTH FLOORS, ALSO THE ELEVENTH FLOOR, ARE SIMILAR.



ELECTRICAL PLAN—FIRST FLOOR OF THE NEW SINGER BUILDING.



ELECTRICAL PLAN—FOURTEENTH FLOOR OF THE NEW SINGER BUILDING. THE FIFTEENTH TO TWENTY-FOURTH FLOORS ARE SIMILAR TO THE FOURTEENTH FLOOR.

not on the loop system. Power feeders for elevator motors and for fan motors are to be run from the switchboard up the shaft back of elevator No. 4. The power feeders are to be two-wire as follows:

One circuit to three electric elevator motors on the roof of the Singer building.

One circuit to the four electric elevator motors on the roof of the Bourne building.

One circuit to the four electric elevator motors on the thirteenth floor mezzanine of the Singer addition.

One circuit to one electric elevator motor on the forty-second floor of the Singer addition, one electric elevator motor on the thirty-ninth floor of the Singer addition and three electric elevator motors on the thirty-sixth floor of the Singer addition.

One circuit to two 12-h. p. fan motors in the basement, to one 18-h. p. fan motor in the basement and to one 12-h. p. fan motor in the basement of the Singer building.

One circuit to one fan motor on the thirty-ninth floor of the Singer addition.

One circuit to one one-half horse-power fan motor in the basement of the Singer addition, to two five-horse-power motors driving iced-water circulating pumps in the Singer addition basement, to one three-horse-power motor driving a sump pump in the Singer addition basement, and to three three-horse-power motor generators in the engine-room.

The sizes and lengths of the power feeders are as follows:

To elevators Nos. 1, 2, 3 and 4 in the Singer addition the cable will be 1,600,000 c. m. about 250 feet in length.

To elevators Nos. 5, 6, 7, 8 and 9 in the Singer addition the cable will be 2,000,000 c. m. about 700 feet in length.

To elevators Nos. 10, 11 and 12 in the Singer building the cable will be 1,000,000 c. m. about 250 feet in length.

To elevators Nos. 13, 14, 15 and 16 in the Bourne building the cable will be 1,600,000 c. m. about 220 feet in length.

To the four fan motors in the basement the cable will be No. 0 B. & S. about 30 feet in length.

To the one fan motor on the thirty-ninth story the cable will be No. 1 B. & S. about 650 feet in length.

To the sump pumps, iced-water pumps, motor generators, fan, paper press, etc., the cable will be No. 6 B. & S. about 120 feet in length.

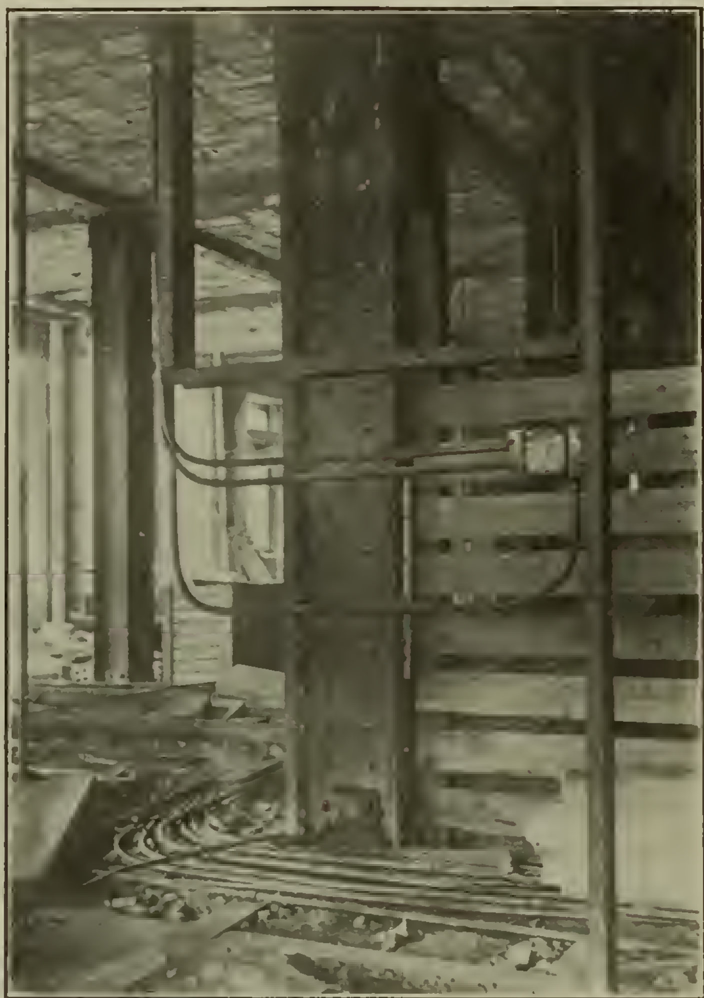
All of the above is to be installed complete with the conduit system.

Conduits for the loop feeders are to have steel junction boxes, and panel-board connections on the various floors shall be made to each cable in these boxes. The connections will be made direct without fuses with Dossert connectors.

Feeder conduits will run along the basement ceiling exposed and in chases in the shaft behind the elevators securely fastened. All feeder conduits, except those in the basement, are to be concealed in the floor or wall construction. They are to be continuous from box to box with not more than four quarter bends between two boxes, and no bend shall be less than six-inch radius, all being bent to a true curve. All conduits will be put together with couplings and standard threads, clean cut and made up watertight with white lead. The conduit will be securely fastened to the junction and outlet boxes, proper bushings being provided to prevent abrasion of the wire. Plugs are to be placed in the open ends of all conduits to prevent the entrance of dirt or other foreign matter. The ends of the conduits are to be reamed smooth before joints are made. The ends of all conduits running down from panel boards or outlet boxes will be sealed with wax after the wires are drawn in to absolutely prevent the entrance of moisture. Horizontal cross runs in partitions are not permitted except for very short distances. The conduits will in every case be kept free from contact with other pipe. Electroduct conduit supplied by The American Circular Loom Co. will be used throughout, free from burrs or rough surfaces, evenly coated and of full standard gas pipe weight; sizes smaller than 5/8-in. interior diameter are not allowed. Hangers will be supplied at intervals of not more than 10 feet, unless the conduit is imbedded in concrete.

A Thomas & Betts steel outlet box will be installed at each outlet. These will be set so that the opening in the cover will be flush with the finished plaster line. Ceiling outlet boxes will be secured to the floor arches by means of anchor plates fastened to the back of the boxes. All outlet boxes are to have threaded fixture studs. Pull boxes will be installed at numerous points. Switch boxes are to be of the same make as the outlet boxes, namely, Thomas & Betts. Panel Boxes will be of 1/8-in. steel secured to framing provided by the building contractor with back, sides and removable covers to gutters well built and braced with angle irons. Partitions between gutters and panel boards will be 1/2-in. slate marbleized and polished on the exposed inside surface. Marbleized slate linings will correspond to partitions and panel boards. All conduit entering the panel box will be secured by lock-nuts and bushings. Panel boards are to be 7/8-in. marbleized slate with bus-bars and fuses neatly mounted, ample spaces being provided between branch circuits and bus-bars. All connections are to be made on the face of the board. Circuit wires are to be secured by binding screws and feeder cables by Dossert lugs. All bus-bars and other copper work will be of rolled copper polished and lacquered. The bus-bars will be protected on the three exposed surfaces by fiber 1/16-in. thick, this being to prevent short-circuits from accidental contact; all such fiber insulation is to be neatly finished and lacquered.

Enclosed fuses are to be provided for all feeders and circuits which will be mounted on the panel boards. No feeder or circuit-switches are to be on these boards.



SWITCH BOX.

The spacing of all bus-bars on the panel boards is to be arranged for 240-volt three-wire, and neat directories are to be provided on the inside of the door and protected by a glass cover.

Wall switches are to be double-pole flush push-button type with polished bronze face plate, and where several switches are mounted in a gang a common face plate will be provided for all. These switches will be of the diamond H type, manufactured by the Hart Mfg. Co., Hartford, Conn. On thin partitions, mats of calamined iron will be placed around the switch plate. Circuit wiring will be No. 14 B. & S. duplex wire; all wires are to be the Standard Underground Company's Tip Top. All wire No. 8 and larger is to stranded. No wire is to be used smaller than No. 14 except for fixtures. Wires will not be pulled into conduits until the plastering is completed. The insulation resistance must be not less than one megohm between wires or between wires and ground, after the entire wiring installation has been completed and the various connections made.

The electric range now in the Singer Company's kitchen on the roof of the present Bourne building is to be moved to the new kitchen on the north side of the 34th floor.

One complete set of extra fuses is to be provided.

Instead of installing wall outlets for bracket fixtures in the offices, it was decided to put in receptacles for portable lights. It is expected that these receptacles will be of more use to the tenants for lighting desks and tables

SWITCH BOX—WALL READY FOR PLASTERING.

than the brackets would have been; general illumination is provided by the ceiling fixtures. Where the side outlets are located near wash basins, the brackets will be retained.

All wall switches, receptacles and brackets throughout the offices were located on the columns and permanent walls rather than on the partitions. The partitions can accordingly be shifted without necessitating alterations of the electrical work.

All receptacles below the 14th floor will be placed in the baseboard of offices with the bottom of the plate two inches above floor; above the 14th floor they are to be placed above the base. All exposed steel conduit boxes and supports will be painted with two coats of Voltax paint to prevent corrosion.

Three search-lights for 40-amp., 220 volts with water-tight casings, reflectors, diffusers, cut-out blocks, etc., are to be installed on the roofs of the 13th story portion. The arcs are to have prismatic reflectors so made as to throw the strongest light on the top of the tower and to give diminishing intensity toward the base. They are also to have shutters so adjusted that the light will be cut off sharply on the outline end of the tower, showing the tower brightly against a dark background. One search-light is to be mounted on the top of the tower on a movable truck and arranged to travel around the flagpole and pass the ladders, pipes and trap doors, also pivoted vertically and horizontally upon the truck.

The outside of the tower from the 34th story up is to be illuminated by incandescent lamps concealed from view either by the architecture of the building or by shades on the lamps. These lamps are to have reflectors so as to throw the light on the outside of the tower and supplement the illumination from the search-lights on the lower part of the tower. The size of feeders for the incandescent lamps is to be 600,000 c. m. Reflectors are to be of aluminum with the outside to match the building.

The conduit to the tower incandescent lamps is to be run exposed on the masonry. Where copper sheathing is encountered, the conduit is to be run back of the sheathing with outlets extending through the sheathing. In every case the hole around the socket is to be made watertight. All outside lamps are to be 16-c. p. 220-volt.

The outside lighting may be modified before completion.

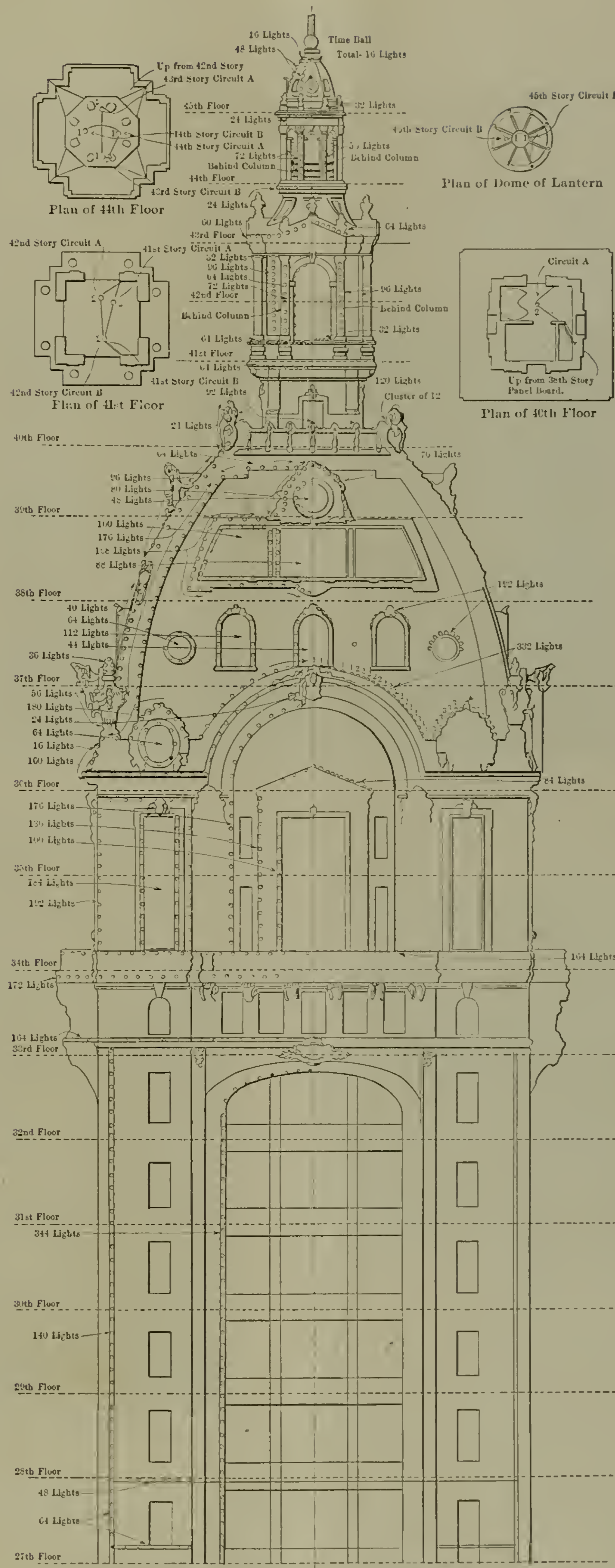
Incandescents will be located as follows, the location given being for one side of the building only:

- 34th. floor 41 lamps on each balcony rail; total, 164.
- 36th floor—21 lamps on the top of each pediment over center windows; total, 84.
- 36th and 37th floors 83 lamps on large central arch, the two bull's-eyes and the flat attic coping between them; total, 332.
- 37th floor—10 lamps on top of each of three large windows and 9 lamps at each bull's-eye window; total, 192.
- 39th floor 19 lamps around bull's-eye window; total, 76.
- 40th floor—18 lamps on each side of the square distributed and 12 in a cluster; total, 120.
- 41st floor—8 lamps on balustrade of balcony; total, 32.
- 41st and 42d floors—12 lamps in a vertical row behind each column, total, 96.
- 43d floor—16 lamps on top of gable and attic; total, 64.
- 44th floor—7 lamps in a vertical row behind each column; total, 64.
- 45th floor—4 lamps on each face; total, 32.
- Crown at base of flag-pole; total, 16.

The total of all lamps on the outside of the tower is 1264. This number will probably be increased to about 1600.

The illustration on this page shows two proposed schemes for lighting the tower. The one to the right and designated as estimate No. 5 has been adopted.

It will be noted that the table of lamps per floor and the plan show 45 stories in the new Singer building. Usually, however, the building is said to be 42 stories high only, the 43d, 44th and 45th floors being in the cupola. The total height from Broadway to the top of the tower is 672 ft.; a time ball will be erected at this point, where it will be visible from the greater part of lower Manhattan.



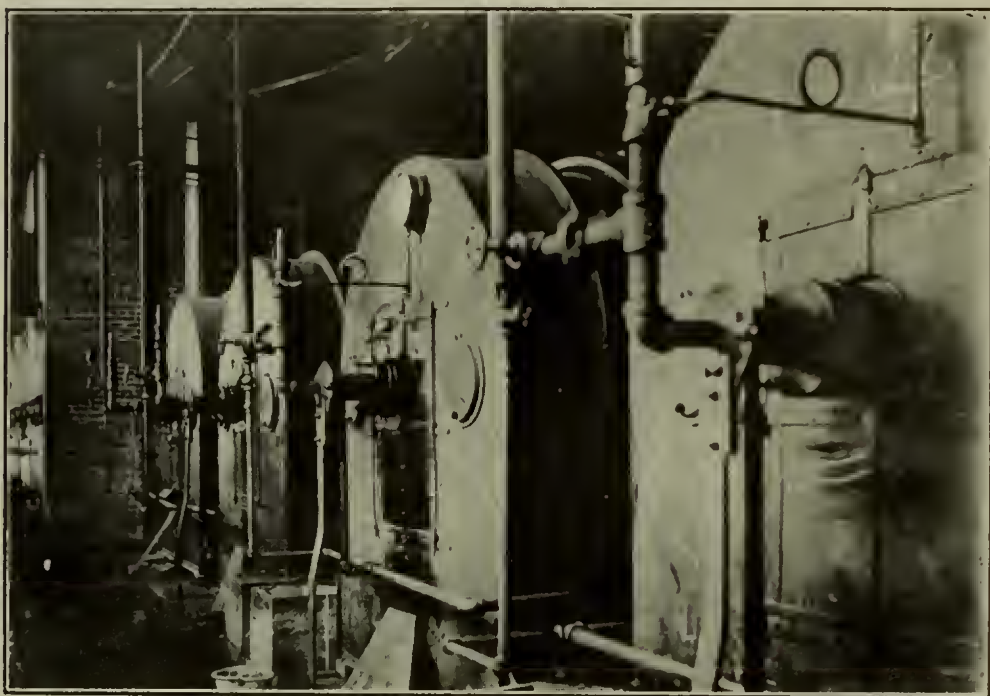
This Side shows Lamps as called for by ESTIMATE # 6

This Side shows Lamps as called for by ESTIMATE # 5

Power Station and Electric Equipment

JOSEPH STEHLIN

A BY-PRODUCT of breweries known as "grains" is an excellent feed for cattle, and is used quite extensively in its wet state for this purpose in districts adjacent to the breweries. For shipment, however, this material must be thoroughly dried, this process being conducted on a large scale by the company whose plant is described herein.



ROW OF ELECTRICALLY OPERATED DRYERS.

The material as received is first compressed to remove surplus moisture. It is then conveyed to dryers, where it is subjected to steam heat until all moisture has been removed. During the drying process the dryers are revolved, thus mixing the grains and gradually transferring it from one end of the dryer to the other, from which point it is discharged into conveyors and carried to the storage bins. Next it is transferred to the shipping department, where it is packed in bags for export.

Formerly this work was done entirely by steam engines belted to the different conveyors and dryers. Lately the steam equipment has been replaced and supplemented by a steam-power plant and complete electric motor equipment, this addition being made under the direction of the Stehlin-Miller Company, electrical and mechanical engineers, 59th Street and Madison Avenue, New York.

Considerable difficulty was experienced since the old plant was necessarily kept in operation while the new machinery was being installed, and much of the work at the present time is temporary, awaiting the opportunity to be placed in final location.

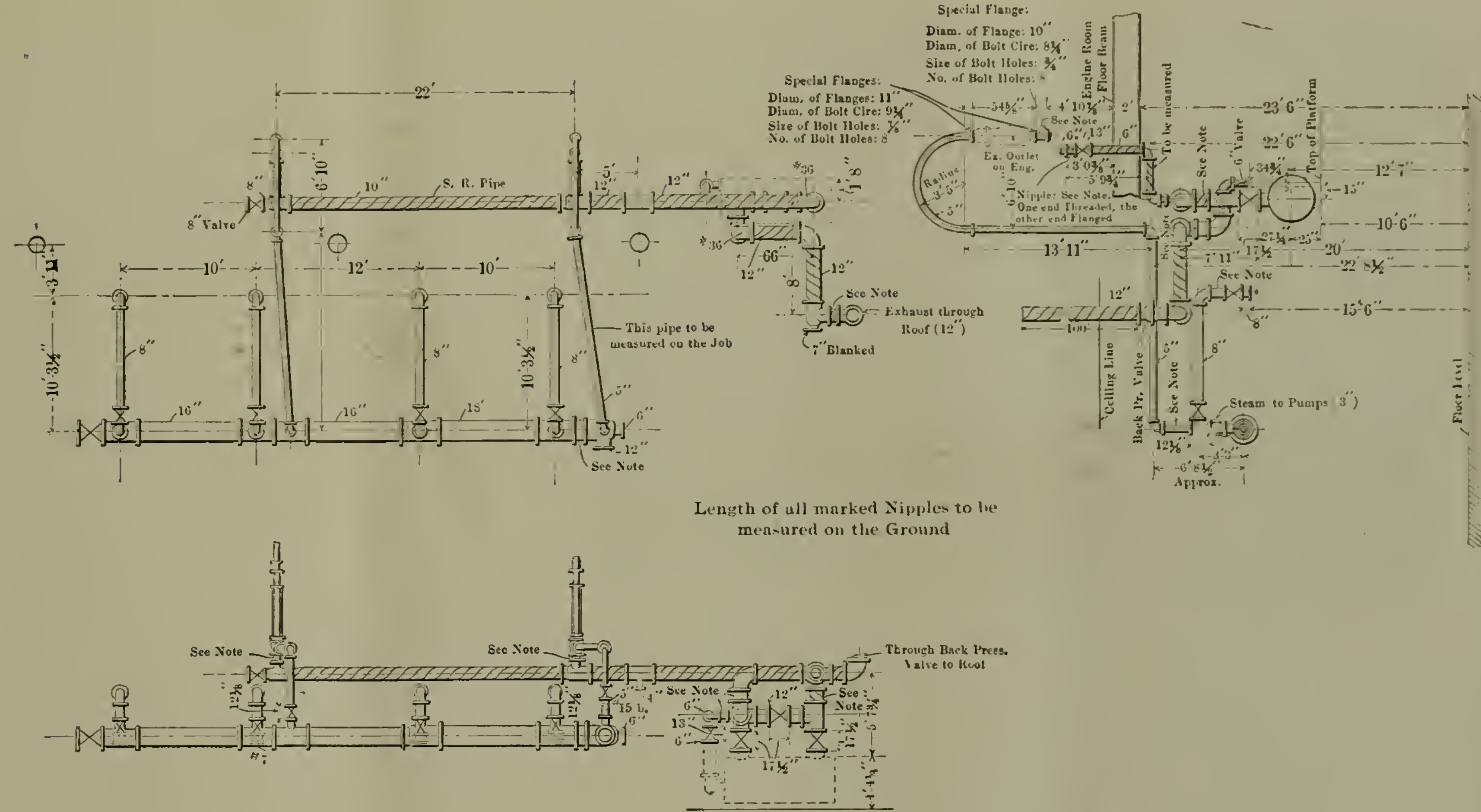
The power plant consists of four Parker boilers of 275 horse-power each and two 100 kw. Western Electric generators direct-connected to Buckeye engines of 150 i. h. p. each. The electric system is operated at 240 volts two-wire. There are four 10-horse-power Sprague electric motors running at 400 r.p.m., each belted to a dryer and two 10 horse-power Sprague motors belted to the conveying apparatus. One of these last two motors operates two grain presses and the wet grain conveyor, the other handling the dry grain conveyor.

A moist vapor is given off from the grain which is very injurious to metal, for which reason the motors were made entirely enclosed, outside air being supplied to the motors for ventilation through air ducts.

Owing to this moisture it is also necessary to adopt marine fittings for the wiring. Russell and Stoll marine type fittings are used throughout for the incandescents, as they are both dust and moisture proof. The wiring is rubber-covered, enclosed in iron conduit with every precaution to exclude the injurious gases and to relieve the conduit of moisture from condensation. Main feeders from the switchboard distribute the electric energy to numerous panel boxes located at convenient points about the building. The lighting is controlled from these panel boxes, which are fitted with tight-fitting covers to exclude dust and moisture and provided with locks and keys so that only authorized persons can turn on and off the light. Circuits to motors are run from the switchboard direct, each motor having a separate circuit which is controlled by a switch and enclosed fuses both at the switchboard and at the motor.

CONNECTION OF MOTOR TO DRYER.

The arc lamps in the engine-room have fluted steel enameled reflectors.



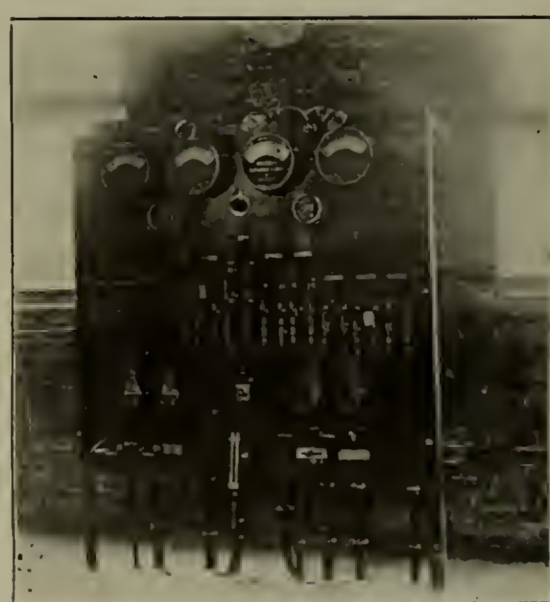
LAYOUT OF STEAM PIPING.

All other arc lamps in the boiler-room and outside lamps have clear outer globes which have been found to give the best service in these locations.

TWO OF THE BOILERS.

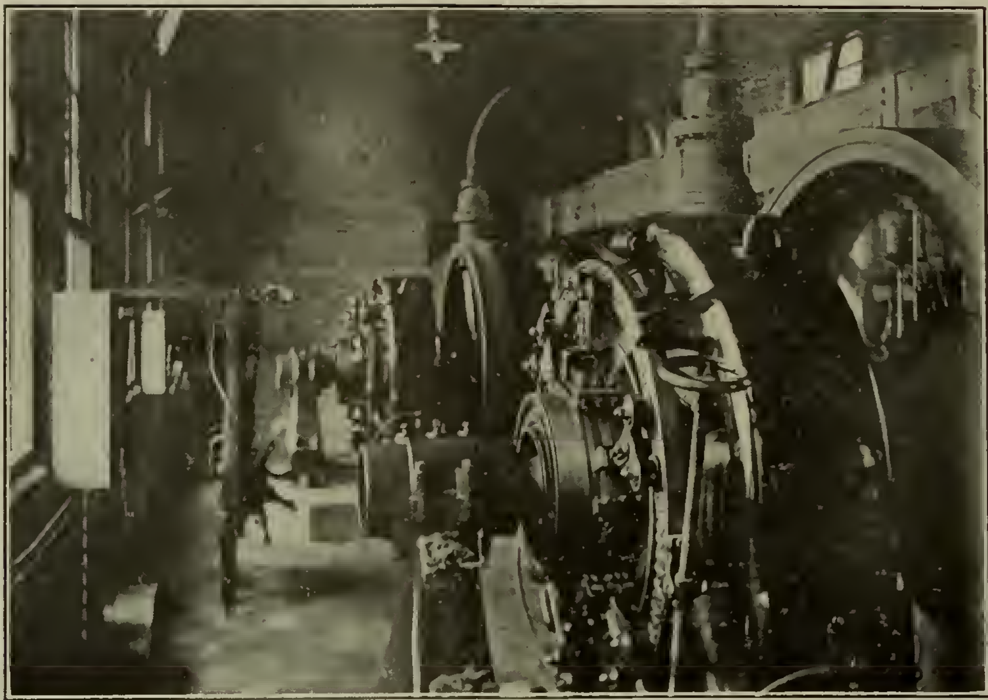
Portable incandescent lamps are installed at numerous points. Each portable lamp consists of from 25 to 50 feet of portable lamp cord with Russell and Stoll marine type guard screen and socket for connection to marine type receptacles, located at convenient points. Receptacles are also provided in the offices for attaching electric fans when found desirable.

The boiler steam-pressure is 125 pounds. This is reduced to 90 pounds by Foster reducing valves for supplying the dryers; the engine generator sets are operated at 125 pounds—the boiler pressure. The return from the dryers is conducted to Burrows steam traps, thence to a closed tank, from which point it is pumped by Fair-



SWITCHBOARD.

banks-Morse pumps to the boilers. The supply to the boiler feed pumps is regulated by a float valve. The pressure of the return is approximately 70 pounds, so that the feed pumps are working with pressure at the intake. It will be seen that with this system the only loss in the steam used for drying is that due to the actual heat given up in the process of



POWER PLANT.

water is returned to the boilers, and there is no extra cost for this water except that due to leakage.

The exhaust steam from the engines in the power plant is conducted first to a feed-water heater, where all drying the grains; moreover, the extra water required for operation is heated before being fed to the boilers. From the feed-water heater the exhaust steam will pass through one of the drying machines to be utilized in drying grains, from which point it is handled through a pump and receiver back into the utility tank, where it is mixed with the water from the dryers and fed into the boilers. The back pressure at the engine exhaust will not be above 2 pounds.

The switchboard was manufactured by the H. O. S. Electric Company, with American instruments and I. T. E. circuit breakers.

The results so far secured by electric operation of this plant have been satisfactory in every way, the reduction in the amount of attention required for operating electric motors over that required for operating the steam engines formerly installed being cited as specially desirable.

Single-Phase Electric Motive Power on the Erie Railroad—Rochester Division

W. N. SMITH

ONE of the most important electric railway developments of the present year is the change from steam to electrical motive power on a portion of the Rochester Division of the Erie Railroad, which took place on the 18th of June, 1907. This is the first installation of a single-phase alternating system of electrical motive power upon a steam railroad.

With this electrification, the priority of application can justly be claimed of several important features, which are of interest in connection with the discussion now prevailing upon systems best suited for steam railroad electrification. This railroad company was the first to operate electric cars on the single-phase system over the tracks of an operating steam railroad; the first to use 11,000 volts working pressure commercially on a trolley in this country, and the first instance of a heavy electric traction system receiving power from a 60,000-volt transmission line.

All of the construction described below, except that of the 60,000-volt power transmission line and the car bodies and trucks, was designed, executed and placed in operative condition by the Westinghouse, Church, Kerr & Co., engineers, through whose courtesy the drawings and photographs which illustrate this article were furnished.

The section of track equipped for electric operation is 34 miles long, ex-

AVON SUBSTATION—EXTERIOR.

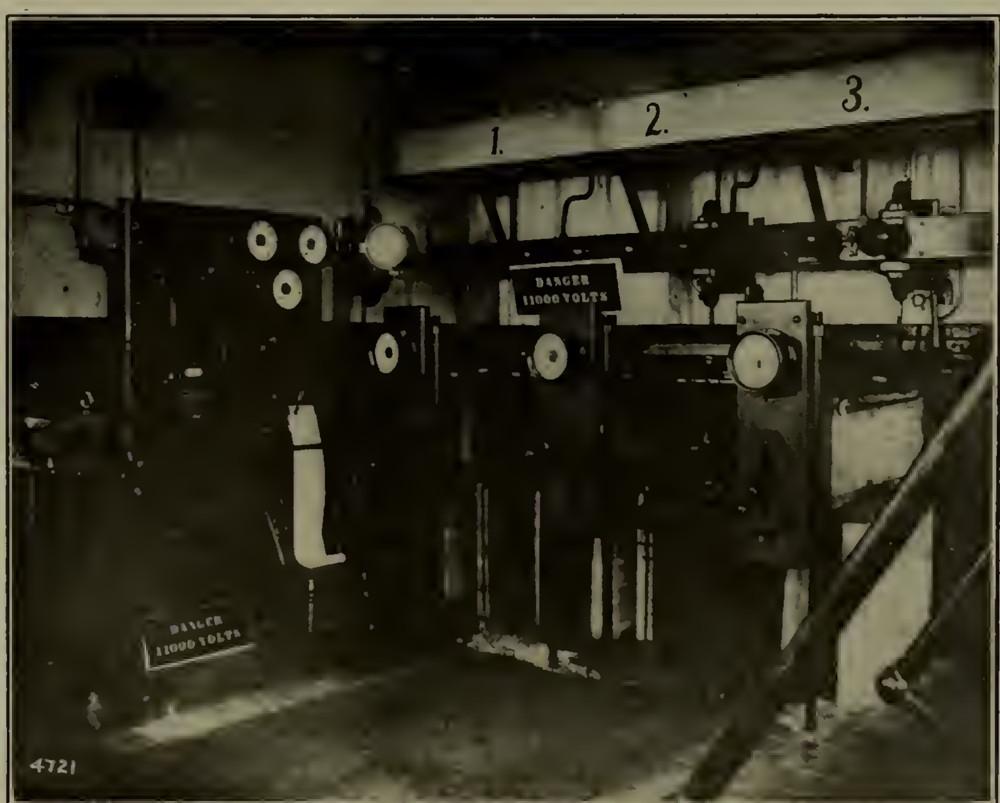
tending from Rochester over the main line of the Rochester Division to Avon, a distance of about 19 miles, thence 15 miles over the Mt. Morris Branch. The railroad is entirely single track, with sidings at way stations, averaging three to four miles apart. The grades are light, and the curvature for the most part quite easy, the line being relatively straight.

The line was originally laid with 68-lb. rails, but was relaid with 80-lb. rails, taken from another division just prior to the electrification. The roadbed is ballasted with gravel, and the joints are of the Weber type. A single No. 2/0 protected rail bond is applied to each rail joint under the plate, one of the advantages of the high-tension single-phase system being that the relatively small current renders it unnecessary to resort to heavy bonding.

The line crosses a number of bridges. The longest one is that over the Genesee River, about a mile and a half south of Rochester, being 780 feet long, and comprising seven spans. There are also through truss bridges at Rush, and at Caneserauga Creek, near Mt. Morris, and a stone arch bridge over Conesus Creek, a short distance south of Avon.

The electric service is devoted solely to passenger traffic, which is of the local interurban type. The principal villages served are Avon, Geneses and Mt. Morris, the other regular way stations being little else than cross-road stops. The population is entirely agricultural, and the Genesee Valley, traversed by this line, is probably one of the most beautiful and prosperous farming regions of New York State.

MAIN TRANSFORMER ROOM IN SUBSTATION.



SUBSTATION OPERATING ROOM—SHOWING 11,000-VOLT SWITCHING APPARATUS.

The freight service is handled exclusively by steam, as heretofore, as are also the through trains operating between Rochester and Corning over the main line of the Rochester Division, a distance of about 94 miles. The steam service between Rochester and Mt. Morris originally comprised three round trips daily. Instead of three round trips per day, the electric service has been the cause of increasing this number to six complete round trips between Rochester and Mt. Morris, and three more between Avon and Mt. Morris.

POWER SUPPLY.

The power is generated at Niagara Falls, in the plant of the Ontario Power Company. It is transmitted at 60,000 volts, three-phase, over the lines of the Niagara, Lockport & Ontario Power Company, whose system has been fully described in former technical papers. The Iroquois Construction Company constructed a branch line from Mortimer, a little over four miles south of Rochester, to Avon, locating it upon the Erie Railroad right of way for nearly the whole distance. The pole construction used upon this branch transmission line is of the A-frame type, using two 40-ft. cypress poles, set abreast of each other, and inclined so that their tops are framed together, the butts being joined by horizontal plank braces underground. The cross arms consist of two three and one-half by six inch timbers, eight feet long. The insulator pins are of cast steel, one being placed at the apex of the A frame and the other two bolted near the extremities of the cross arms, so that there is an equilateral spacing of seven feet between each of the three wires. The insulator pins are grounded by copper wire. The neutral of the transmission system is grounded at the power station through a resistance. Lightning protection of the horn arrester type has been installed at every fifth pole. The conductors are of No. 4, hard drawn, stranded copper cable. The standard length of span between poles is 220 ft., which is shortened at curves where necessary. When crossing over the tracks of the Erie, or other rail-

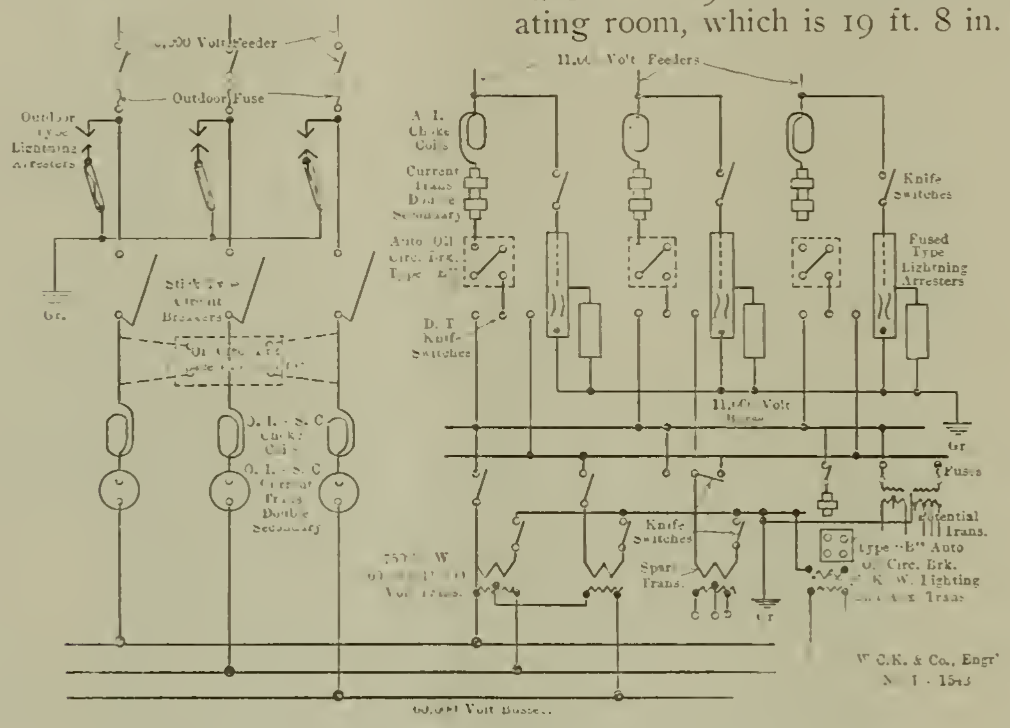


DIAGRAM OF CONNECTIONS—ERIE SUBSTATION, AVON, N. Y.

roads, recourse is had to a special construction of No. 0 copper cables carried on steel towers, so reinforced by guys that it is impossible for a failure of the line to result in dropping the conductors across railroad tracks.

SUBSTATION BUILDING.

The substation building is located in the Y formed by the railroad tracks at Avon, and, together with the car shed, is adjacent to the roundhouse and division repair shop. The walls of the building are of brick, resting upon solid concrete foundations, the roof and floors being of reinforced concrete. The floors are supported upon steel beams, but the roof beams are of reinforced concrete, like the slabs which they support.

The building is absolutely fireproof, the doors and windows being of kalomein construction, and fitted with wire glass. The building is 39 ft. 8 in. x 44 ft. on the outside, and 29 ft. 10 in. high from the top of the foundation to the top of the parapet. The door sills and lintels are of concrete blocks, and, for architectural effect, a belt of concrete blocks runs around the building, at a level of the window sills. The parapet is topped off with a coping of concrete blocks.

In the basement of the building are located one of the transformer oil tanks and the oil pump. The main floor is divided into three rooms, the main transformer room being 43 ft. x 17 ft., and extending the full height of the structure to allow room for the high-tension bus bars, which are carried over the transformers. The remaining space on the main floor is divided into a high-tension room (through which the 60,000-volt wires enter, and in which are located the high-tension circuit breakers) size 16 ft. 8 in. x 19 ft. 8 in., and the operating room, which is 19 ft. 8 in. x 24 ft., where are located all the 11,000-volt switching apparatus and the measuring instruments. Directly over the operating room is a mezzanine floor, reached by an iron staircase. The 11,000-volt lightning arresters, 60,000-volt choke coils, and the 60,000-volt series transformers are located on this mezzanine floor. The high-tension connections enter through the high-tension room, which runs from floor to roof, and pass through the choke coils and series transformers, on the mezzanine floor, and then turn through a wide opening in the wall to the 60,000-volt bus-bars, which are located in the upper portion of the transformer room.

There is space in the transformer room for another transformer of the same size, and there is also space in the high-tension room for an oil insulated circuit breaker should it ever be decided necessary to install one there. The interior of the building is painted with cold water paint of the same light green shade that is commonly used by the Erie Railroad for interior finish.

The interior lighting equipment consists of 47 16-c.p. incandescent lamps. Heat is furnished by a simple system of colonial wall type steam radiators, supplied by steam from the locomotive roundhouse.

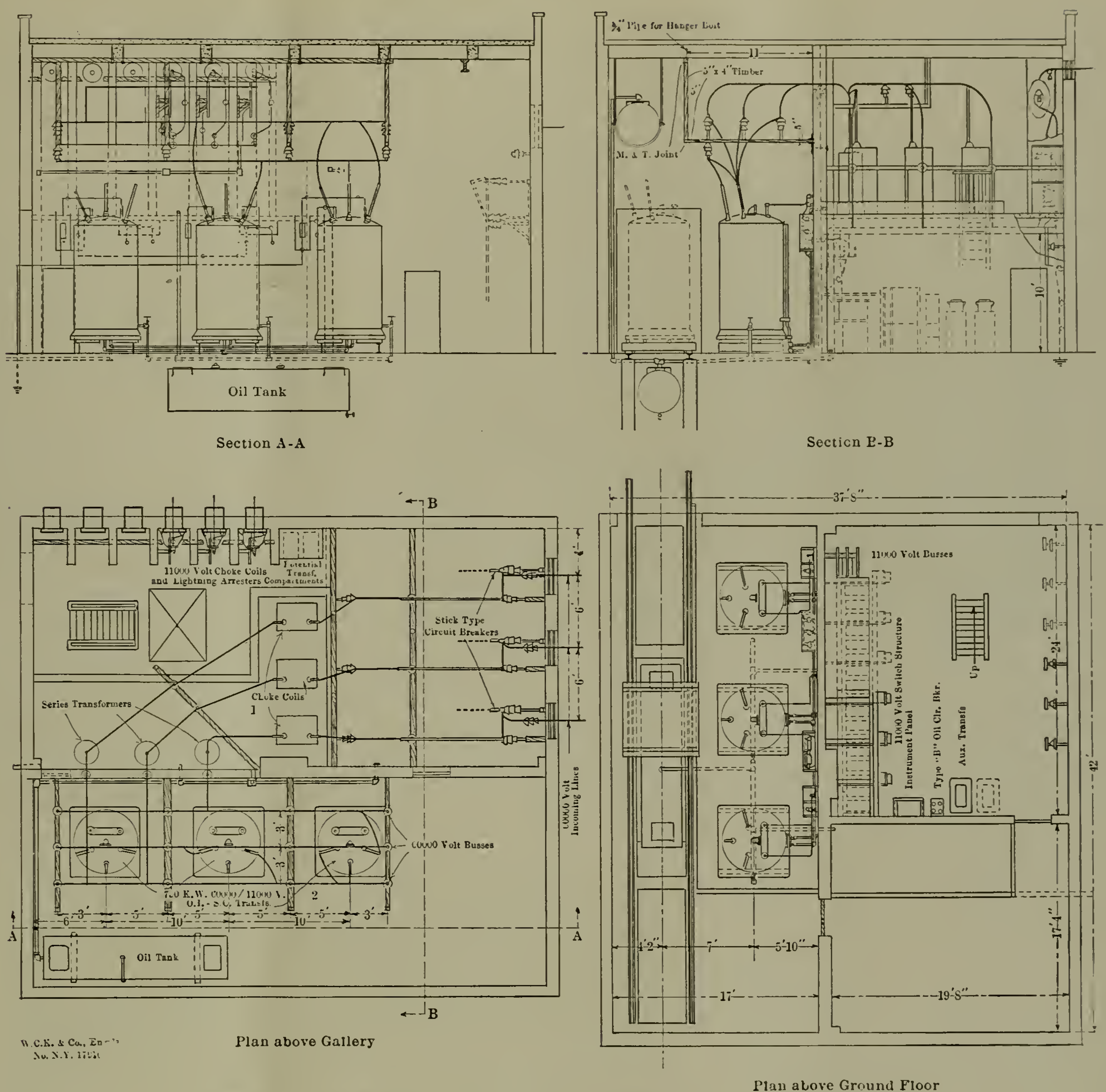
SUBSTATION EQUIPMENT.

The transmission line terminates at the lightning arrester yard in the rear of the substation. The arrangement of the 60,000-volt lightning arresters consists of three horn gaps, arranged one behind the other, on each of the three conductors, the first gap being four and three-quarter inches across, the second five inches, and the third six inches. A concrete column is in series with the first gap, an electrolytic arrester in series with the second and a five-foot fuse of No. 18 copper wire in series with the third, that is to say, between one horn and the ground. Both horns of each gap are of ½-in. round iron. Between the line and the first arrester there is a hook-type knife switch, and between the last arrester and the lead into the substation there is a No. 18 copper wire fuse, in each conductor, placed horizontally upon the structure especially devised for it on top of a pole. These fuses are enclosed in wooden tubes about five feet long, wrapped with torpedo twine. The entire arrangement of lightning arrester gaps, fuses and switches is mounted upon 18 chestnut poles; and a suitable elevated platform, railed off and fitted with a gate to keep out trespassers, affords means of access to the apparatus when attention is required.

The three high-tension conductors enter the substation through glass discs held in 36-in. tile, set in the upper portion of the rear wall of the substation.

Within the substation the wires first pass through three 60,000-volt stick-type circuit breakers, mounted directly inside of the rear wall, thence over bare copper conductors to the three oil insulated choke coils, situated on the mezzanine floor, and thence to three oil insulated series transformers, also on the mezzanine floor. Connections are taken from the series transformers to the power measuring instruments in the operating room. The main connections finally terminate upon a set of copper bus-bars in the transformer room. These bus-bars are run upon porcelain insulators mounted on wooden cross arms placed at a convenient height directly over the line of transformers.

The 60,000-volt three-phase current is rendered available for single-phase distribution by means of three transformers of the Westinghouse oil-insulated-water-cooled type, each of 750 kw. capacity. For the present installation, two transformers only are used at one time, the third being a spare. The high-tension connections are such that in case of one transformer failing while in service, its connections can quickly be taken off the bus-bars, and put on the spare transformer. The transformer windings are fitted with taps enabling the three-phase to two-phase "Scott connection" to be used. The low-tension windings can be so connected that either 11,000 volts or 22,000 volts can be obtained,



GENERAL ARRANGEMENT OF ELECTRIC APPARATUS—AVON SUBSTATION, ERIE RAILROAD.

so that in case it should ever be desired to transmit railway current for an extension of 40 or 50 miles, to another substation, it could readily be done without adding transformers to this equipment. The low-tension windings also have six taps, enabling relatively small variations in the secondary voltage to be obtained if the same should be necessary to suit operating conditions in the trolley line.

One end of each low-tension winding is directly grounded to the boiler iron case, which in turn is, by means of a 4/0 stranded copper cable, directly connected to the track return circuit.

The transformer cases are made of boiler iron; each is set on a square cast-iron base, which is in turn mounted on three pairs of wheels running upon an iron subbase set in the concrete floor of the room. A track runs lengthwise of the room directly in front of the transformers, a transfer truck running upon it. Upon the top of the transfer truck there is another set of little wheels or rollers, which line up with those upon which the transformer cases are set. When it is desired to remove the windings from the transformer case, it is only necessary to disconnect the electrical, water and oil connections, roll the transformer off its subbase, and on to the truck, which is then pushed to the rear end of the transformer room where it comes directly under a 10-ton hand hoist, which is able to lift any part of the transformer that repairs may make it necessary to handle.

Two cylindrical boiler iron oil tanks are provided, each of slightly greater capacity than a single transformer. One is located in the basement directly under the transformer room, so that the oil from the transformer can readily be drained into it. The other is suspended from the concrete roof beams at the top of the transformer room, close to the side wall of the building, this being intended to act as a reservoir for distributing oil back into the transformer. The oil is pumped from the lower to the upper tank by means of a steam pump supplied from the boiler room in the adjacent division roundhouse, where steam is always available. From the upper tank, oil is fed by gravity into either transformer. It is thus a simple matter to draw the oil off from any transformer if its insulating qualities are found to have depreciated; and the dehydrating, filtering or purifying apparatus can readily be employed with the aid of the pump, and the supply returned again to storage. The oil piping is of iron throughout.

The water circulation is by gravity, the supply coming from the railroad company's water-tank system, at the adjacent roundhouse, being pumped, originally, from the Genesee River, about a mile distant. An artesian well had been opened up on the premises, but the water was so strongly impregnated with sulphur and other impurities, that it was thought best not to introduce it into the copper piping in the transformers, although the cost of such a supply would have been practically nothing.

There are three separate water-cooled coils in each transformer case, each one controlled by its own valve, so that the amount of water may be controlled as found necessary under various conditions of load.

The necessary transformation from three-phase to two-phase fits in very well with the natural subdivision of the electrified line, into two sections, one of which is about 19 miles in length, north of Avon, the other being about 15 miles in length, south of Avon. The connections were, therefore, laid out to operate these sections upon separate phases of the two-phase secondary system. Either the T or V connection can be used, the latter method being employed at present. Each one of the active transformers therefore feeds a separate section.

As mentioned above, one terminal of each single-phase 11,000-volt transformer is grounded. The middle transformer of the three is ordinarily used as a spare, and the ungrounded low-tension lead from this transformer runs to the center of a double-throw switch, whose outside poles connect separately to two low-tension bus-bars. The ungrounded low-tension terminals of the other two transformers connect through single-pole switches, one to each of these bus-bars.

The low-tension bus-bars run along the wall of the operating room, and directly beneath them are three type E Westinghouse automatic oil circuit breakers, one on each of the two trolley feeders, the third breaker, which is situated between the other two, being a spare. One pole of each of the three oil breakers is connected to the center pole of a double-throw hook-type knife switch, by means of which it is thrown upon either bus-bar. The other pole of each of two oil breakers is connected directly to a feeder. The outgoing lead from the middle or spare circuit breaker can be readily thrown upon either one of the feeders, should the breaker usually controlling that feeder be temporarily disabled. This system of connections is simple, compact and flexible, and has admirably fulfilled the conditions for which it is intended.

The outgoing 11,000-volt feeders run up to the mezzanine floor directly over the operating room, where they emerge from the building through perforated glass discs, set in 18-in. round tiles. Before emerging, there are tapped to them two Westinghouse low-equivalent lightning arresters, set in brick compartments, and reinforced by two electrolytic lightning arresters of the 11,000-volt type. A set of call bells is provided so that, when the automatic breakers open, a bell is rung in the car-inspection shed, near by. Also, if the temperature of any transformer runs above normal, a bell circuit connected to a thermometer in the top of the transformer tank is similarly made to operate. The station itself does not require the continuous presence of an attendant, which is needed in the case of a rotary converter substation. The working force is so organized that the car repair men are always available for manipulating the substation circuit breakers and the cost of attendance is thereby reduced to a minimum.

(*To be Continued*).

The Electrical Show at Madison Square Garden

THE Electrical Show recently held at Madison Square Garden was notable in that the exhibits consisted of electric appliances adapted to household use, to machine-shop operation and to lighting in distinction from exhibits in former shows, which consisted largely of new inventions that had not proved their value in industrial work.

F. Alexander Electric Company had an exhibit of arc lamps, which was unique on account of the size of the lamps shown. They have a three ampere miniature arc lamp which gives 500 actual candle-power while consuming 330 watts. This lamp was shown with a number of assortments of glassware and reflectors.

The Consolidated Telegraph and Electrical Subway Company had in their booth samples of cable composed of different arrangements and sizes of conductors and showing different methods of installation. Manhole construction was clearly demonstrated by a full-size model.

The Driver Harris Wire Company showed a complete line of resistance wires.

The Edison Illuminating Company, of Brooklyn, had one of the most instructive and popular exhibits for the general public. Their exhibit consisted of a model apartment equipped for electric operation. A refrigerating machine operated by an electric motor was shown and the statement made that the cost of running this machine by electricity is about half the cost of ice. A clothes-washing machine, consisting of a tub in which washing was done, a wringer connected to the tub and a special driving mechanism for transmitting the power from a miniature electric motor, either to the wringer or to the washing equipment, demonstrated a method of solving the servant-girl problem. Electric flat irons were used in conjunction with the washing machine and completed the laundry equipment. Hot water was always obtainable from an electric water-heater. A dish-washing machine capable of handling frail china was another demonstration of interest in the kitchen. A complete electric range with utensils, including broiler, griddle and stoves was very attractive. Electric plate-warmers were used to advantage and an electric coffee grinder did effective work. Polishing machines were also shown in the kitchen. The dining-room equipment consisted of an electric coffee percolator, an electric tea-kettle, an electric chafing-dish and an electric plate-warmer. Passing from the dining-room to the parlor a vacuum cleaner was encountered, which was certainly very effective in its work. The parlor contained an electric grate, an electrically operated piano and very handsome electroliers. The bedroom electric equipment consisted of an electric heating-pad, an electric curling-iron heater, an electric milk warmer, an electric radiator, and an electrically operated massage outfit. The library was also completely equipped with modern conveniences operated electrically. An electric fountain, sewing machine, sterilizer, telharmonic music and cigar lighter were all viewed with intense interest. The illumination of this department was planned by Van Rensaeller Lansingh; three-way switches being used to a large extent.

The Electrical Testing Laboratories had an instructive exhibit consisting of standard resistances, testing sets and numerous other instruments of value for calibrating and testing electric equipments.

The Federal Sign Company had an attractive exhibit of electric signs.

The General Electric Company have used their space, which was equivalent to eight booths, for an array of motor applications and electric heating and cooking devices in order to make their exhibit of wide interest to the general public. The interest shown in their exhibit was a vindication of the wisdom and desirability of this idea. The exhibit was laid out with a main booth roofed with an arched canopy forming a galaxy of light and two open wings on each end.

EXHIBIT OF THE EDISON ILLUMINATING COMPANY OF BROOKLYN.

EXHIBIT OF THE NEW YORK EDISON COMPANY.

The front wing was devoted to the motor household and culinary applications and electric ironing. The visitor could demonstrate personally the advantages of the electric-driven sewing machine, potato peeler, the ice-cream freezer; and observe the clothes both washed and ironed. Of particular interest was the electric carpet renovator in which a motor drives a cylindrical brush, and a centrifugal fan produces a suction at the brush and delivers the dust into a receptacle; absolutely no dust escapes into the room. There were also on exhibit in this wing motor-driven dough-mixers, coffee grinders and meat choppers.

To further heighten the interest in this wing a moving-picture machine was placed there illustrating graphically the exciting race between the General Electric Company's electric locomotive and a New York Central flyer running seventy miles per hour. There was also an electrically operated Regina music-box which discourses sweet strains.

The main booth was devoted to a model dining-room and a model kitchen. The former was furnished in mission. Over the table hung an ornate shell dome in which was a 40 c. p. tantalum meridian lamp. The electric cigar lighter and the corn popper on the table were suggestive dining-room conveniences; the electrically wired side table on which were an electric chafing-dish and percolator, indicated the best way to provide for these modern necessities. The electric fan was not omitted.

The model kitchen exhibited the electric kitchen cabinets, large and small size, on which busy demonstrators were preparing delicious biscuits, fudge, rarebits and other delicacies.

A counter along the side was stocked with a complete assortment of electric heating and cooking appliances, many in operation, for examination by the curious and interested. Perhaps the article on this counter attracting the most attention and exciting the greatest comment was the Electric Luminous Radiator. Already the inquiries regarding this device have resulted in many sales.

The end wing was devoted to industrial applications.

Attracting considerable attention, partly on account of its noise, was an Ingersoll-Temple Rock Drill in operation. A three horse-power motor drove an air compressor and pulsator, the energy being transmitted to the drill through the medium of compressed air. It is a machine which combines both the advantages of the pneumatic and purely electrical drills. A one horse-power motor drove a cabinetmaker's circular miter saw. The greatest interest on the part of the general public was probably evinced in connection with the mercury arc rectifier automobile charging set, which was in operation, with switchboard equipment. Of special mention, however, was a 30 kw. four-cylinder, direct-connected, gasolene generator set which the General Electric Company was just placing on the market. A new electrically-driven floor sander in which a two horse-power motor drove a 15-inch sanding drum was in use for demonstrating. A 20 kw. Curtis turbine steam generator set used for train lighting and a disassembled turbine showing the advantages of construction; also a Bridgeport double 12-inch emery planer driven by a two horse-power induction motor and numerous small motors for various applications, completed the exhibit in this wing.

GENERAL VIEW OF SHOW FROM RIGHT-HAND GALLERY.

On the left side of the main booth, a color booth of four sections had been placed, each section being lighted by a standard illuminant, viz., enclosed arc, Welsbach gas, incandescent, and Nernst. This color-comparison exhibit was an educational feature for the purpose of illustrating the effect of artificial illuminants on colors. It demonstrated, for example, that silks or dry goods of any color can be purchased or matched by the light of GE enclosed arc lamps which correspond most closely to natural daylight. The conditions are entirely reversed by the use of other illuminants; for instance, blue appeared green when viewed under other illuminants, such as gas and incandescents.

The crowds were so great, and the interest manifested in the General Electric Company's exhibit so intense, that a large portion of the New York office had to be pressed into service to answer inquiries, there being 12 or 15 men present. The exhibit was in immediate charge of Mr. W. J. Canning, who is in charge of electric cooking and heating sales in the New York territory. Miss Winifred S. Potts, in the household departments, was assisted by five lady demonstrators.

Among those from out of town were Mr. C. C. Chesney, manager Pittsfield Works; Mr. F. H. Gale, in charge of advertising, exhibits and electric heating appliances; Mr. H. B. Wilson, of the heating department, Pittsfield; Mr. E. L. Callahan, electric heating department, Chicago; Mr. C. E. Dibble, small motor department, Chicago; Mr. J. O. Case, exhibit engineer and Messrs. H. J. Mauger and H. Fulwider, electric heating department, Schenectady.

A. Grothwell had an exhibit showing the efficiency of Mogul paint applied to numerous electric devices as a protective compound.

G. M. Gest exhibited numerous samples of conduit.

India Rubber & Gutta Percha Insulating Company had very complete samples of Habirshaw wires, cables and cores for every class of service, among which was a section of a telephone cable containing 109 conductors protected by a lead sheathing, asphalt and steel covering for submarine use. This was stated to be cut from the largest telephone cable installed to date.

The Advertising Mirrorgraph Company had a complete line of signs and flashers.

The Kenney Co. showed their line of electric devices to advantage.

The Monoton Construction Company took numerous orders for electric installations.

The Marconi Wireless Telegraph Company appealed to the public by sending messages from one end of the hall to the other, where they were received and reported.

The National Dairy Supply Company had on exhibit a Burrell-Lawrence-Kennedy cow milker and a number of cows, this feature proving of great interest to the general public on account of the exhibit of live animals.

GENERAL VIEW OF SHOW FROM MADISON AVENUE END OF BUILDING.

The National Electric Lamp Association, composed of the following companies, The Banner Electric Company, The Brilliant Electric Co., Bryan-Marsh Co., The Buckeye Electric Co., The Colonial Electric Co., The Columbia Incandescent Lamp Company, Economical Lamp Co., the Fostoria Co., the General Incandescent Lamp Co., the New York & Ohio Co.,

EXHIBIT OF THE NATIONAL ELECTRIC LAMP ASSOCIATION.

The Shelby Electric Co., the Standard Electric Manufacturing Co., The Sterling Electric Manufacturing Company, and the Sunbeam Incandescent Lamp Company, had a very attractive booth in which were shown the numerous types and makes of lamps now in the market, among which were several of exceedingly high efficiency.

The New York Edison Company exhibit was composed mainly of electric applications of machines for household and shop use, among which were a Day dough mixer, a portable grinder made by the Chicago Pneumatic Tool Company, an American floor surfacing machine driven by a Crocker-Wheeler motor, a coffee mill and meat chopper, potato peeler made by the Robertson Machine Company and operated by a one-half horse-power Eck motor, a Brooks centrifugal pump, supplied by the Dayton Hydraulic Machine Company, and several electrically operated presses from the Hill Publishing Company.

The New York Beck Lamp Company had their lamps distributed about the building besides showing models in their booth. The arc of one lamp was enclosed by a red glass globe clearly showing the shape of the arc.

The New York Telephone Company was represented.

Thomas Prosser & Son had an attractive booth.

Fried Krupp showed cast steel Krupp machinery and steel forgings.

Reinhold Lewitz had a model of a flying machine on exhibition.

The Safety Car Heating and Lighting Company gave a demonstration with their car lighting electric equipment, both the load and the speed of the driving mechanism being varied between wide limits without affecting the voltage at the lamp.

Schimmels Dairy Exhibit consisted of the electric operation of milking machines.

Standard roller bearings were well illustrated by models of bearings shown in section.

The Telharmonic Music Company exhibited in connection with the Brooklyn Edison Co., and entertained a large crowd with musical selections.

The Warren Electric & Specialty Company exhibited their line to good advantage.

The Metropolitan Engineering Company showed electric signs, electric sign motors, motors, heating appliances and cooking devices.

The American Wire Brush Company showed their Minerva wire brush for cleaning castings; it is also adapted to sweeping.

The W. Green Electric Company had on exhibition a very attractive line of small motors operating buffing, polishing, grinding, drilling and lapping lathes. Their lines of plating dynamotors, demagnetizers, electric clocks, and Westminster electric chimes were also of interest.

The Westinghouse Exhibit was a joint exhibition of the numerous companies comprising the Westinghouse interests. The main feature of the Westinghouse exhibit was their display of motors driving industrial machines. The following is a partial list of machines driven by the Westinghouse motors:

Pipe cutting machine:
 Curtis & Curtis
A. B. C. rotary fan:
 A. B. C. Company
Vacuum cleaner:
 Sanitary Device Company
Exhaust fan:
 American Blower Company
Centrifugal pump:
 Watson & Stilwell
High-speed air compressor:
 Rotong Eng. Company
Blakeslee dish washer:
 Blakeslee & Company
Perforating machine:
 Simpson & Son
Commercial graphophones:
 Columbia Phonograph Company
Stafford loom:
 Stafford Company
Singer sewing machine:
 Singer Sewing Machine Company
Day dough mixer:
 John Day Company
Ironing machine:
 American Ironing Company

Westinghouse motors were also used in connection with milking machines, supplied by Schimmel's Dairy Company. The Westinghouse Company had quite an interesting exhibit of motors not in operation, consisting of back-geared, belted, direct-connected and vertical types. These motors range from ⅛ h. p. to 50 h. p. The display of Westinghouse transformers consisted of oil and air-cooled, also of the manhole type, ranging from one kw. to 20 kw. The detail apparatus display of the Westinghouse Company consisted of a varied display of switchboard and portable instruments. The following is a partial list of some of the instruments:

Graphic recording power-factor meter and graphic recording wattmeter; both of these instruments are in operation. The switchboard instruments consisted of synchroscope, power-factor meters, vertical ammeters and volt meters. A special feature of the integrating wattmeter display was the prepayment wattmeter. This meter was in operation. The lightning-arrester exhibit consisted of a standard low-equivalent lightning arrester panel mounted and connected to its auxiliary parts. The arc lamp display consisted of direct and alternating enclosed and semi-enclosed types. The main features of the arc-lamp exhibit was that of the flame arc lamp, which was in operation. The display of fans blowing the well-known Westinghouse pennants furnished a unique and interesting feature.

The Nernst Lamp Company had a demonstration of their 110 watt 100-c. p. lamp on their special wall fixtures and brackets. This furnished a brilliant display as a decorative and commercial light. They also gave demonstrations of lighting the glowers and general working of the lamp. Three glower inverted lamps shown on top of each column around the Westinghouse spaces crowned the exhibit.

The Westinghouse Lamp Company attracted a great deal of attention by their interesting display of lamp manufacture, the actual operation of tabulating the bulb and sealing the filament was shown by the latest type of machine and operators from their New York factory. Special wattmeters were shown side by side showing the consumption of current by a tungsten and a standard carbon lamp of equal candle-power. The instruments showed a saving of $66^2/_3$ per cent. in favor of the tungsten lamp.

EXHIBIT OF THE WESTINGHOUSE INTERESTS.

The Westinghouse Machine Company had on exhibit samples of their large plates used for regulating fluctuations of load on street railway plants. They also had an exhibit of glass jars, rubber cells and detail parts used in connection with storage batteries. They had quite a neat exhibit of storage batteries of the automobile sparking type. The construction of the Westinghouse Machine Company's storage-battery plates involves the most recent improvements, the capacity of these plates being guaranteed for ten years.

Suspended in mid-air above the Westinghouse spaces were quite a number of Cooper-Hewitt mercury vapor lamps. These being the only vapor lamps hung in Madison Square Garden, they attracted a good deal of attention. The type K Cooper-Hewitt lamp was used in this display. It is 45 inches long.

The space assigned to the United Electric Light & Power Company was denoted by a large sign 8 ft. high and 32 ft. wide, containing the name of the company and the words "Alternating Current." Directly under this sign was a space 32 ft. by 28 ft., covered by an arch 5 ft. high and 4 ft. wide, on which the name of the company also appeared. The top of this arch was lighted by 50 c. p. tungsten lamps in 8-inch Holophane globes. Around the upper border of this arch 20 c. p. metalized filament lamps were studded. Under the arch the company made a display of all types of incandescent illuminants—carbon, tantalum, tungsten and Nernst lamps burning in profusion. The booth proper was divided into four parts, devoted respectively to electroliers, power, heating and cooking, and industrial exhibits. In the industrial exhibit were shown two very good uses of alternating current—the National Biscuit Company's plant at 15th and 16th Streets and 10th and 11th Avenues; also the newest type of spot welding machine, made by the Universal Welding Company, which machine can only be operated by alternating current.

In the power corner of the exhibit were shown single, two and three-phase motors in operation with centrifugal and reciprocating pumps, variable speed single-phase motors, sewing-machine motors, massage machines, cash registers driven by alternating-current motors and a phonograph similarly operated. An electric carpet-cleaning machine and a coffee mill in operation were also interesting parts of this exhibit.

In the cooking and heating branch of the company's exhibit the Prometheus Company exhibited all kinds of electric irons, hot-water bottles, boilers, percolators, chafing-dishes, curling irons, plate cleaners and electric radiators. The Simplex Heating Company exhibited an electrical range. All these heating and cooking devices were connected in circuit.

EXHIBIT OF THE UNITED ELECTRIC LIGHT AND POWER COMPANY.

In the electrolier portion of the booth one of the most beautiful displays of electroliers ever seen in the Garden was shown. These were from the factory of the Duffner-Kimberly Company, 11 W. 32d Street, and John

Wanamaker. This exhibit of electroliers represented a valuation of over $4,000. In this same corner was also located a branch office of the United Company, where contracts were taken, souvenirs distributed, and a register taken of the names of the visitors to the booth. Advertising material describing the various uses to which alternating current can be put was distributed by uniformed employees of the company.

The entire arrangement of the United Company's exhibit was taken care of and installed under the personal supervision of Mr. F. W. Smith, Secretary of the Company.

Report on Economy Tests

7500-Kw. Westinghouse-Parsons Steam Turbine

THE following data comprises the principal results obtained during the eight-hour economy test on September 1, 1907, upon turbine No. 253 installed earlier in the year at Waterside Station No. 2, of the New York Edison Company. This test was conducted entirely by the New York Edison Company, under the direction of Mr. J. P. Sparrow, chief engineer. The various arrangements therefore, were carried out in accordance with a mutual agreement between builder and operator entered into previous to the test, and the results, as here given, were obtained by independent computation.

The turbine unit tested is of standard Westinghouse construction throughout. It has a maximum rated capacity of 11,250 kw., and was built to operate on 175 lbs. steam pressure, 28 in. vacuum and 100° superheat. Under these conditions, the turbine unit was guaranteed to have a minimum steam consumption of 15.9 lbs. per kw. hr. at the generator terminals with a normal speed of 750 r. p. m. Incidentally, the electrical efficiency of the generator was guaranteed to be 97.8 per cent., exclusive of friction and windage, at a load corresponding to that sustained during the test. The results of the tests, detailed below, show an economy about 7.5 per cent. better than the guarantee.

METHODS OF CONDUCTING THE TEST

Load:

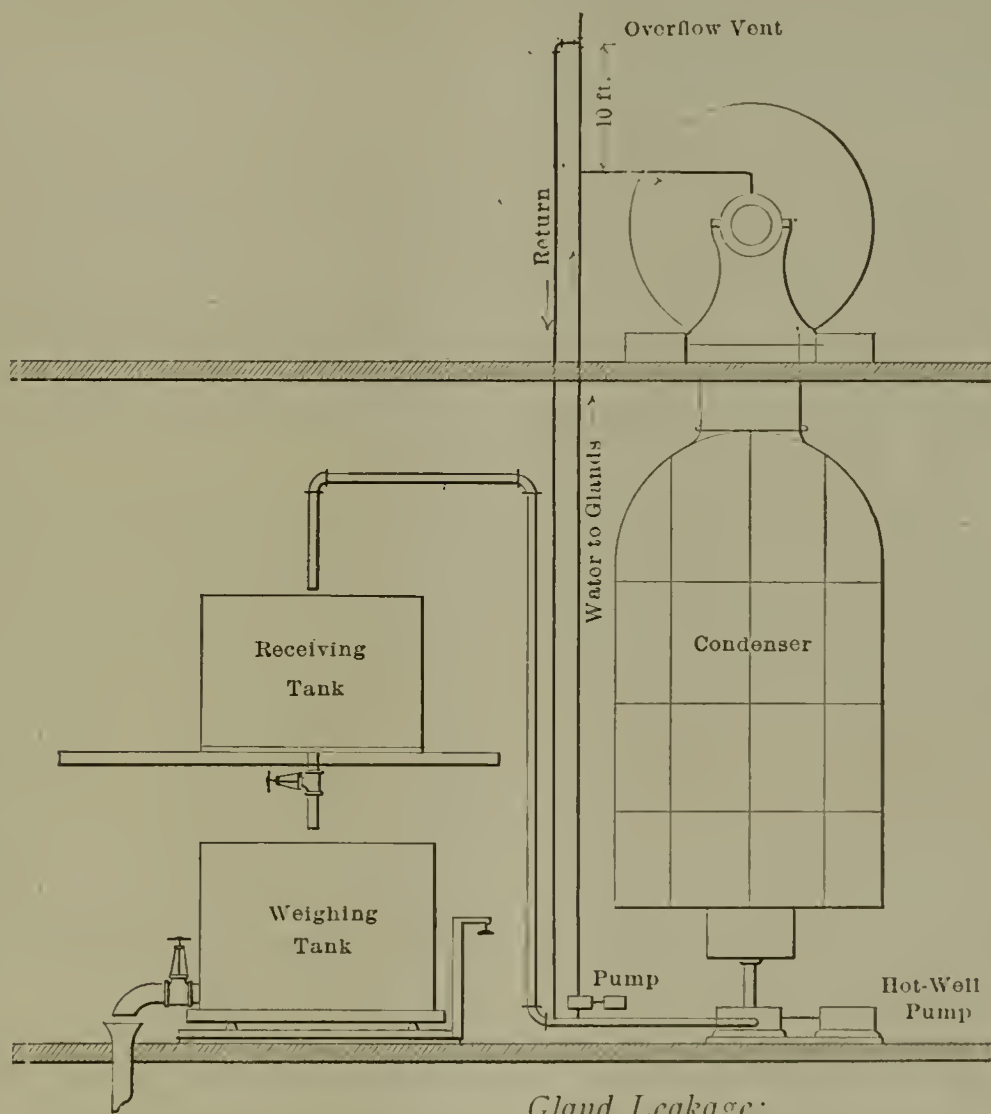
During the test period, No. 2 Waterside Station sustained practically all of the 25-cycle load on the system, of which the unit under test carried practically 70 per cent., the remainder by the other turbine units in the station. This load was maintained as constant as possible by remote control of the turbine governor by the switchboard operator. Between the first and the last hours of the test, the maximum variation in load was held within four per cent. above and below mean. During the last hour, however, the load decreased somewhat. Previous to the test, this turbine unit had been running on a load of 7000 kw., which was increased to its test load 10 minutes before the start.

Calibration:

Three-phase electrical load was measured by the two-wattmeter method, using two Weston indicating wattmeters of the standard laboratory type. These instruments were calibrated at the New York Electrical Testing Laboratories immediately before and after the test. Power factor was maintained substantially at unity, and all electrical readings were taken at one-minute intervals.

Steam Consumption:

As a surface condenser was used in connection with this turbine unit, the water rate was determined by weighing the condensed steam delivered from the condenser hot well. This condensation was weighed in a tank mounted upon platform scales, with a reservoir above large enough to hold the condensation accumulating between each weighing. See the accompanying sketch. These weighings of 12,000 to 13,000 lbs., each, were made at intervals of five minutes.



Gland Leakage:

By the loop method of connecting the gland water supply, shown in the attached sketch, the necessity for correcting condensation by an amount equivalent to the weight of the gland water used is avoided. It will be noted that a continuous gland water circuit is used entirely outside of the weighing apparatus, and that all overflow from the standpipe returns to the hot well delivery.

Condenser Leakage:

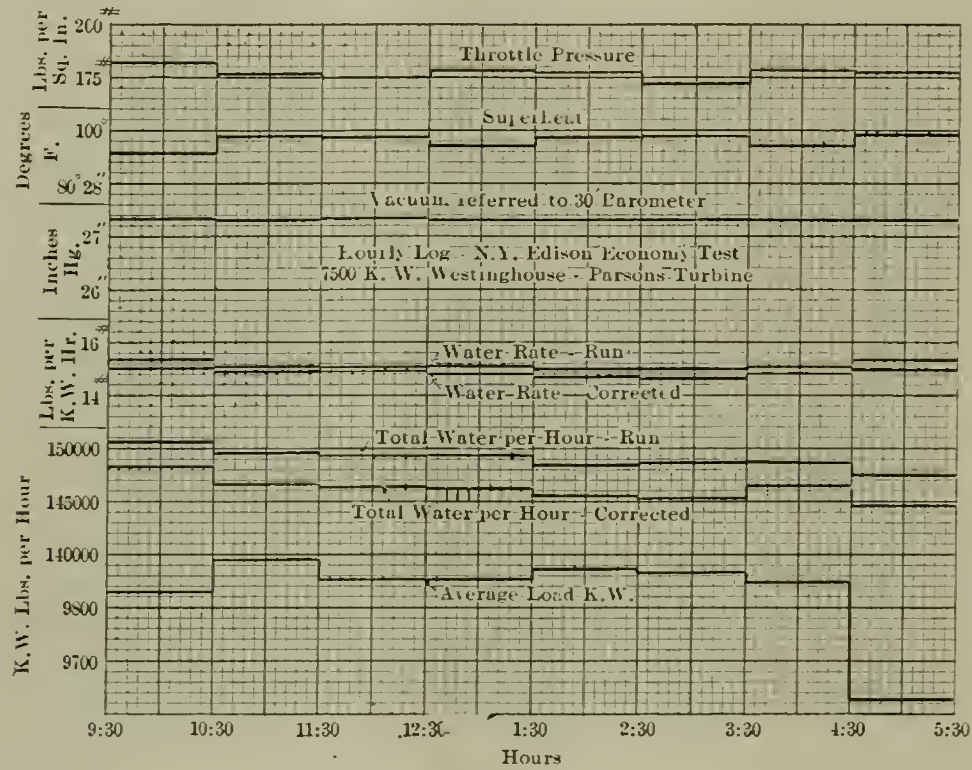
As the circulating water is quite salt, any condenser leakage may immediately be detected by the salinity of the condensed steam, which should be pure distilled water. On this account, condenser leakage was determined entirely by chemical analysis, employing the silver-nitrate test with a suitable color indicator. This method proved extremely sensitive, and possessed a decided advantage over the ordinary method of weighing the leakage accumulating during a definite period when the condenser is idle and under full vacuum. As samples of circulating water and condensed steam could be taken at the same time, this method made it possible to discover any change in the rate of condenser leakage taking place during the test, while the method of weighing, above described, provides only an average result during the period.

Hot Well Correction:

In this condensing plant, the delivery of the hot well pump is automatically controlled by a float valve in the interior of the hot well. This maintains the water level therein at a practically constant point, and hence no correction had to be made for difference in level of water in the hot well before and after the test.

Steam Supply:

Steam pressures and temperatures were determined close to the turbine throttle. As usual, the degree of superheat was obtained by subtracting from the actual steam temperature the temperature of saturated steam at the corresponding pressure carried at the same time. All gauges and thermometers were calibrated previous to the test at the U. S. Testing Bureau. It will be noted that both pressure and superheat were somewhat below the guarantee.



RESULTS OF TEST.

Vacuum:

Vacuum was measured directly at the turbine exhaust by means of a mercury column with a barometer alongside for reducing to standard barometer—30 in. This also obviated the necessity for temperature correction between the two mercury columns. During the test the vacuum was not maintained quite up to normal.

RESULTS OF TESTS.

The following data represents the results of the tests, calculated for the conditions as actually run; *i. e.*, for instrumental errors only:

Duration of test	9.30 A. M. to 5.30 P. M.
Average steam pressure at throttle, lbs. per sq. in. gauge	177.5
Average superheat at throttle, degrees F.	95.74
Average vacuum (referred to 30" barom.) in. Hg	27.31
Average load on generator, kw	9830.48
Average steam consumption, as tested, lbs. per kw. hr	15.15

Test Correction:

Owing to the departure, during the test, from specific operating conditions upon which guarantees were based, it was necessary to correct the observed results by the following amounts:

Pressure (2.5 lbs. high) correction, 0.25 per cent.; vacuum (0.69-in. low) correction, 1.84 per cent; superheat (4.26° low) correction, 0.29 per cent.

These corrections were mutually agreed upon previous to the test as representative of this type of turbine. When applied to the observed steam consumption given above, the following results, representing contract conditions, are obtained:

Average corrected water rate during 8-hr. test, lbs. per kw. hr	14.85
Guaranteed water rate, lbs. per kw. hr	15.9

Log:

Referring now to the accompanying log, it is interesting as a check upon the average figures above presented, to observe the results segregated into hourly periods, as shown. Here it will be noted that the load was considerably lower during the first and last hour than during the main part of the test. Neglecting, therefore, these two hours and considering only the six-hour period from 10:30 A. M. to 4:30 P. M., the results are as follows:

Average corrected water rate, six hours, lbs. per kw. hr	14.8
Equivalent water rate, lbs. per b.h.p. hr	10.65
Equivalent water rate, lbs. per i.h.p. hr	9.8

The two latter quantities are determined by applying conversion factors for generator efficiency and for internal losses.

In connection with these tests, a noteworthy agreement exists between the results noted and those previously obtained from tests of machines similar in design installed in the Manhattan Station of the Interboro Rapid Transit Co., New York, and the Long Island City Station of the Penna. R. R. At the same loads and with equivalent operating conditions, the performance of the machines is almost identical. These economic results, while not exceeding in actual steam consumption the best records of European practice, yet are extremely good in view of the moderate operating conditions under which the test was conducted.

An Alternating Current Coal Mining Installation at the McKell Coal & Coke Co.'s Plant, Kilsyth, W. Va.

AFTER operating their Kilsyth mine for a number of years, using electric haulage of the rack-rail type and employing electric power for various purposes in and about the mines—generating the current at 275 volts close by the bank mouth—the McKell Coal & Coke Company, which was a pioneer in the New River field of West Virginia, realized the necessity of supplying electric power for their newer operations farther up Loup Creek. From the following facts, furnished by Timothy W. Sprague and Charles K. Stearns, Consulting Engineers, and given out by Allis-Chalmers Company of Milwaukee, who furnished the principal power and electrical equipment, it may be seen how advantageously this problem was solved.

The first plan considered was the placing of other power plants at each operation. Lack of water during a portion of the year was, however, an obstacle in the way of this plan, and further, it meant a large increase in operating expense, each plant requiring its own engineers and firemen. Moreover, the distance between the new operations, and from the existing plant to the new operations is too great to allow of direct current or low voltage transmission. Further than this, the installation of such individual low-tension power plants would meet the requirements temporarily. The extent of the coal to be eventually mined and handled over the tipples is so great that the cost of distributing electric power over the entire territory from those stations in the form of direct current, would largely offset the economy of its use.

The establishment of a central station from which power could be distributed to the many points needed was the logical solution of the problem; and, naturally, the location of this station, other things permitting, should be, as its name indicates, in the center of the entire property. This, as has already been said, was not feasible, owing to lack of suitable water supply, and that requirement led to the final choice of Kilsyth for the new generating apparatus. Besides being the nearest point to the power center where a water supply was available, it further offered the advantage of combining the new with the already existing power plant, which it is necessary, or at least advisable, to maintain in its existing shape for the present.

The power requirements of the McKell properties, like all mining operations, are steadily and constantly increasing, and this fact, with the present needs, fixed the size of the first unit to be installed for the transmission work at 500 kw., with a station proportioned for a second unit within the same building, and space available for an extension of the building to accommodate a third unit, should it be found necessary.

The existing boiler plant, consisting of four horizontal tubular boilers, was increased by the addition of four 72-in. by 18-ft. boilers of the same general type.

The engine is of the Allis-Chalmers Corliss type, 26-in. x 42-in, running at 125 r. p. m., with a normal steam pressure of 115 pounds. This is direct connected to a 500-kw., 25-cycle, 6600-volt, 3-phase, Allis-Chalmers generator, revolving field type, with 24 poles. It is separately excited by a 20 kw. Allis-Chalmers generator wound for 230 volts, direct connected to a high-speed engine.

The switchboard consists of three panels of Vermont marble. The generator panel carries the usual direct-current instruments for exciter circuit, three alternating current ammeters, and a three-phase indicating wattmeter. It also carries the controlling wheel of the field rheostat, its switch, a synchronizing plug for an additional generator and an operating lever controlling a triple-pole, single-throw, non-automatic, 6600-volt oil switch, placed three feet in the rear of the board. A swinging bracket attached to the board carries an alternating current voltmeter with illuminated dial, and a Lincoln synchronizer.

The feeder panel carries three alternating current ammeters, a power factor indicator, static ground detector, a three-phase recording wattmeter, and an operating lever controlling a triple-pole, single-throw automatic, 6600-volt oil switch, with overload relay.

The exciter panel carries the usual direct-current meters and equipment, with the addition of a lighting switch and a switch by which current from the direct-current generators already installed may be used for excitation in case the regular exciter is out of commission for any reason.

Lightning arresters are placed where the line wires leave the power-house, though ventilating cupolas and

POWER-HOUSE OF MCKELL COAL AND COKE CO. AT KILSYTH, W. VA.

disconnecting switches at the same point allow the cutting out of the entire equipment from the line wires when shut down.

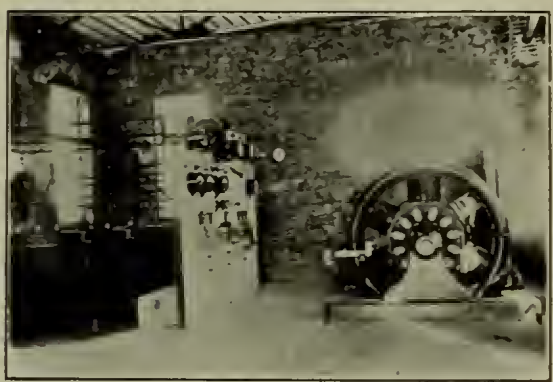
The transmission line from Kilsyth to Sydney substation consists of three No. 2/0 copper wires carried on high-tension porcelain insulators, supported by iron pins. The three wires are placed in the form of a triangle, in cross-section about 28 inches on a side. The top wire insulator is carried on an iron ridge pin and the other two are held by iron pins supported by a southern pine cross arm 3 feet long, 26 inches from the top of the pole. The poles are largely second-growth chestnut, 35 feet in length, 7 inches top diameter and 12 inches diameter 6 feet from butt. At crossings, 40-foot poles are used and protection provided in case of breakage. Poles are set from 5 to 7 feet in the ground.

From the Oswald substation to the Graham substation the same form of construction is used, but the size of wire is only No. 4. The amount of copper installed is sufficient to supply double the present capacity of the substation with a line drop of 10 per cent.

At each substation are located transformers reducing the alternating current to a voltage of 160 for conversion to direct-current at 250 volts, through rotary converters, all of Allis-Chalmers Company's manufacture.

At Oswald the substation is equipped with a 300 kw. rotary with equivalent transformer capacity. This substation supplies direct current for locomotive haulage, coal cutting and other minor uses, in the Sydney mine close by the station, and also for the same uses in the Oswald mine, the bank mouth of which is across the stream from the substation.

At Graham a 200 kw. rotary supplies the Graham mine. Each sub-



SUBSTATION OF MCKELL COAL AND COKE CO. AT SYDNEY, W. VA.

station is designed for an increase in capacity to double the present installation, and each contains a four-panel switchboard. The 6600-volt current first passes through an automatic oil switch placed in a concrete cell at the rear walls of the building and controlled from the switchboard. The same panel carries three alternating current ammeters and a voltmeter on a swinging panel. The second panel carries an ammeter for low tension alternating current and three single-pole, double-throw, main switches for the rotary. In operation these switches are thrown down for starting, connecting thus the rotary to half voltage taps in the transformers and the regular running position is up. Field break switches are placed on the frames of the rotaries themselves, as are also the equalizer switches for future equipment. The direct-current panels carry their usual direct-current generator and feeder equipment for two main circuits and an auxiliary direct-current lighting circuit. The main circuit and each feeder circuit are protected by circuit breakers, and both alternating and direct-current lines are provided with complete lighting arrester equipments. The incoming and outgoing lines pass through tiled openings in the rear walls and the alternating current lines are provided with disconnecting switches.

The substations, like the main station, are of stone, with concrete floors and foundations, and the substations have steel truss roofs, with slow-burning wooden roofs, covered with a roofing composition.

Those substations are located to reduce the direct-current distributing distance as much as possible and at the same time place them where the small attention required may be conveniently given by employees at the tipples, or on other portions of the outside works. The main direct-current circuit breakers in each station are provided with a contact device by which a bell is rung and also lamps lighted, when the circuit breaker is out, giving both a visible and audible alarm.

The three mines are provided with Clifford-Capell fans, and owing to the heavy demand for power which these fans when run at their full capacity will make, they are operated by alternating-current motors entirely independent of the substations. The Sydney and Oswald fans located at No. 4 and No. 5 respectively are 11 feet in diameter, 4 feet 4 inches in width, with 9-inch shaft and are rated to deliver 100,000 cubic feet of air each per minute against a 3-inch water gage pressure. Under these conditions the fans would run at 230 r. p. m. and require about 80 horse-power each.

The Graham fan is the same pattern, 9 feet in diameter, 3 feet 6 inches wide, with a 7-inch shaft, and is intended to deliver 75,000 cubic feet of air per minute against a 2-inch gage pressure. This requires a speed of 200 r. p. m. and about 40 horse-power for driving.

All three fans are placed with shafts parallel with the mine entries on concrete foundations, with stool and concrete housings, and the motors are placed in concrete houses with wooden roofs. The fans are arranged for exhausting, but can be changed to run as blowers by altering the position of the fan and air passage gates.

Each fan house is provided with lightning arrester equipment and disconnecting switches, where lines enter the fan houses, and the high tension current is controlled by an oil switch placed so that it prevents anyone unaccustomed to the plant coming accidentally in contact with the high potential apparatus. From the oil switch the current is carried overhead along the roof to three transformers which reduce the voltage to 440 volts, for which the motors are wound. The fans are belted to the motors, which are standard three-phase induction type, controlled by compensators.

Each motor is provided with large and small pulleys, allowing a variation in speed, the present requirements being much below the expected ultimate requirements for which the motors are installed. Banks of lamps on the secondary of the transformers, which lamps are to be normally burning, will show an interruption of the current by their darkness, and a visible signal will also be arranged to show an interruption of the fan itself through the same cause or trouble with the motor or belt connection.

The location of the Oswald fan No. 5 is a good illustration of the adaptability and flexibility of the system. At the time the installation was started, it was planned to place this fan near substation No. 2. Later on it developed that a location over half a mile away would materially increase the efficiency of the work of the fan. Were a low-tension generating plant installed at No. 2, the cost of copper to connect a fan requiring 80 horse-power at No. 5 would be considerable, and of course the same statement would be true were it necessary to take direct current from the substation. The cost of connecting on the high-tension lines running from Oswald to Graham and passing within a short distance of No. 5 is entirely negligible, and would not be of great importance had it been found desirable to place the Oswald fan at some other point, even much more remote from the bank mouth.

INDUCTION MOTOR DRIVING PUMP.

In the same way induction or synchronous motors for various purposes, such as the operation of mine pumps, etc., may be placed practically at any points needed in the entire territory, at a nominal copper cost, the voltage of 6600 reducing the size of conductors so that the principal items of expense in such distribution is very materially cut down.

It is equally feasible to place other rotary transformer stations at distant points on the property for direct current distribution underground, and the high-tension current may be carried overhead to a point above the center of such a needed distribution and thence down a bore hole to an underground transformer station similar to the substation already described.

Jeffrey Mining Machines

THE Jeffrey mining machines with flame-tight motors and starters shown in the accompanying illustrations were brought out almost simultaneously with the publication of the British Departmental Committee's report upon the use of electricity in mines. This report, which embodies rules for the use of electricity in mines, recommended the adoption of entirely enclosed motors and auxiliary devices, such as starters, terminals, etc., for all mines coming under general rule No. 8 of the Coal Mines Regulation Act of 1887.

Mining-machine motors, of necessity, have to be designed to be very compact. It is therefore necessary that every advantage be taken of space, so that the motors will not heat excessively under their regular duty. In this country, where our mines are very free from gas, the open type of motor has found favor on account of its accessibility, and on account of the fact that the same motor capacity can be put into smaller space in the open type than in the enclosed type. By careful designing, however, the Jeffrey Manufacturing Company have been able to put upon their mining machines motors of the enclosed type which are of equal capacity to those of the open type formerly used, and the enclosed motors occupy practically no more space than those of the open type.

The Jeffrey 21-A mining-machine motor, which is typical of other enclosed mining-machine motors made by this company, is a modern motor in every respect. The armature is drum-wound with machine-formed coils. The pole pieces are of laminated sheet steel, and the windings of both the armature and field coils are insulated in the most approved manner for mining-machine service. This service, by the way, is probably the most severe of any service which electric motors are called upon to perform. The insulation has to withstand both oil and moisture, as well as heat and infinitely more dirt and less attention than in any other service known. The motors illustrated are provided with self-oiling ring-oiling bearings, which are so arranged that the oil hermetically seals the motor so that any gas which may accumulate about the motor cannot possibly be ignited by sparking at the brushes, or any interior trouble with the motor. Over the commutator of this motor is a plate-glass door, protected by a heavy malleable-iron lid. The brushes may be observed through the plate-glass door without opening the motor to mine gases.

FIG. 1.—21-A COAL CUTTER.

The starting switch for this motor is protected in a similar manner to the motor itself, all contacts being hermetically sealed in flame-tight metal casings.

The inspector for the British Government who recently inspected these motors pronounced them as conforming in every particular to the rules and requirements of the Departmental Committee.

An advantage of these motors is that they can be applied directly to Jeffrey mining machines with no other change than the removal of the existing open-type motors. They are wound for standard voltages of 220, 250 and 500 volts, and may be wound special for other voltages where requirements demand it.

Attempts have been made by manufacturers of coal-cutting machines to develop an enclosed-type motor, which motor would not only conform to the rules and requirements of the English Government, but would at the same time be an efficient motor and one so designed as to reduce to the lowest possible point the expense of maintenance, but up to this time no such motor has been put upon the market by any builder save the Jeffrey Manufacturing Company. This company has not only brought out the 21-A motor for what is commonly designed as the standard type of chain-breast machine, but they have also brought out the 27-A motor which is a motor of the enclosed type conforming strictly to the mining laws and adaptable to low or thin vein machines. The demand for such machines equipped with both of these motors has been very extensive, and since the motors were put on the market machines equipped with same have been ordered by the largest coal companies not only in Great Britain, but in the English colonies where the rules of the home government are effective.

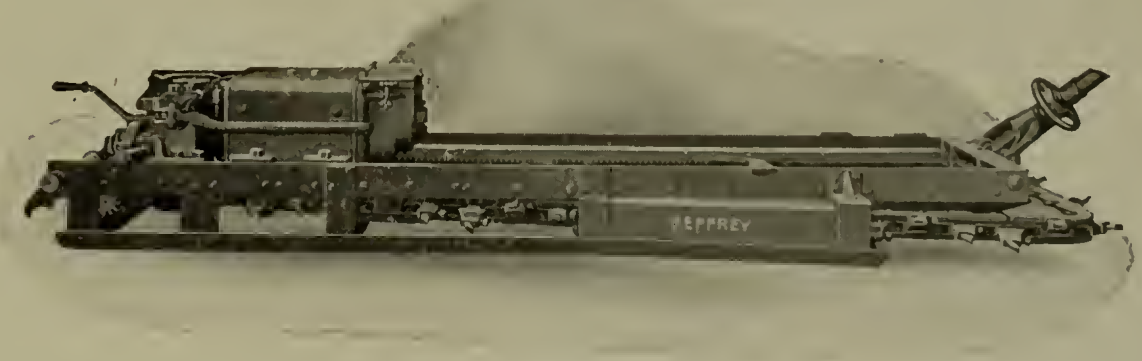


FIG. 2.—27-A COAL CUTTER.

Figure 1 shows the 21-A coal cutter equipped with enclosed-type motor, and figure 2 shows the 27-A coal cutter, which is a low-vein machine, equipped with enclosed motor.

Electric Locomotives—*Continued*

H. L. KIRKER

If we imagine the wire that carries the current to be the axis of the magnetic whirlpool, we can understand why similar parallel currents tend to come together and dissimilar ones to push apart.

Now that we have a moving picture

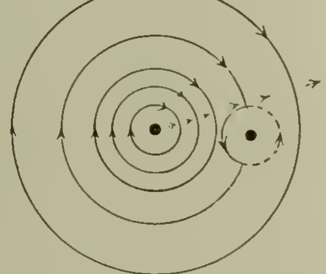


FIG. 6

of an electric current, let us see if we can make our magnetic cyclone brew other cyclones. I will commence with a simple analogy. Drop a stone into still water. You know how the wave rings travel out. Imagine these rings to rotate around the center like our magnetic whirlpool, and to have the continuity of the smoke rings that sometimes emerge from locomotive stacks. Suppose these wave rings, as they travel out, to encounter an obstacle such as a vertical rod. Where the rings strike the rod they will be dented back toward the center and partially encircle the rod before they break and join again on the other side.

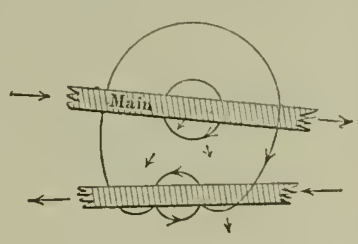


FIG. 7

The dented-in portion of a ring can be considered as a segment of an incipient vortex set up around the rod as a center. The direction of the rotation of this small ring around the rod is counter to the direction of rotation of the main ring around its axis. See Fig. 6.

I will ask you to carry this dented ring portion of the picture in mind, for I will constantly refer to it. It is an illustration of what happens when an electric current is turned into a circuit and its expanding wave rings of magnetism strike a neighboring wire. The dent, as stated, represents an incipient temporary vortex of opposite direction around the neighboring wire. All neighboring wires are possible centers for magnetic cyclones, and respond immediately to changes in the magnetic barometer.

Let the falling stone represent the starting of a current down the vertical wire. Let the wave rings of magnetism set up by this current rotate around the wire in a clock-wise direction. The dented-in portion of a ring, where it strikes the neighboring wire, has a counter clock direction of rotation around the neighboring wire. This counter clock direction of rotation corresponds to a direction opposite to that in which the stone fell. Starting a current, then, in the main wire tends to set up, temporarily, a

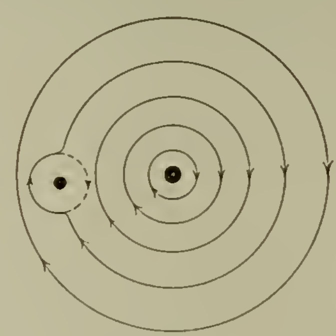


FIG. 8

current of opposite direction in a neighboring wire. See Fig. 7.

The first current having risen to its normal value, the expansion of the rings ceases, and as no more lines cut across the neighboring wire, induction also ceases.

Now interrupt the main current. The encircling rings shrivel up, and those which lie outside of the rod are dented out as they converge on the center. This outward bulge may likewise be considered as a segment of incipient vortex around the second wire. Its direction of rotation is, in

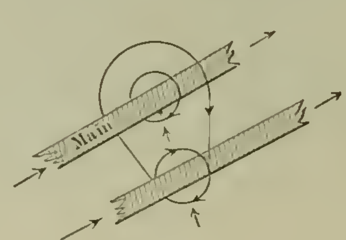


FIG. 9

this case, clockwise, which means that the temporary current induced in the second wire is in the same direction as the current dying away in the main. See Figs. 8 and 9. We see, then, that starting a downward current in the main wire induces an upward current in the second wire, and stopping the downward current in the main wire induces a downward current in the second wire. Starting an upward current in the main wire induces a downward current in the second wire. Consequently, the reversal of the current in the main wire from downward to upward induces a downward cur-

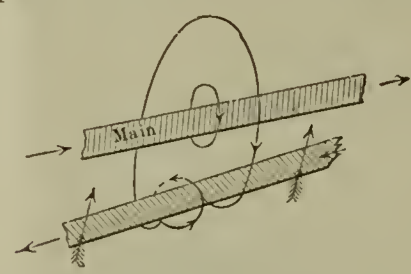


FIG. 10

rent in the second wire. Likewise the reversal of the current in the main wire from upward to downward induces an upward current in the second wire. The direction of the induced current then is such as to oppose the change in the main—if the main current is increasing the induced current opposes the increase by flowing in the opposite direction, and if the main current is decreasing, the induced current opposes the decrease by flowing in the same direction. The action and reaction are equal and in opposite directions.

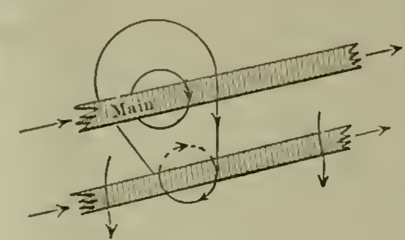


FIG. 11

Suppose, now, that instead of making and breaking the current in the main wire, we allow a steady downward current to flow. We can imagine the wire to be encircled by concentric vortex rings of magnetism whose rotation is continuous in the clock direction, but whose expansion has ceased.

Move the second wire toward the main. First, it dents the vortex rings, then breaks through them, and in doing so sets up around the second wire opposing whirls which correspond to opposing currents. As soon as the cutting movement ceases the induction ceases. If now we move the second wire away from the main, we dent the lines in the opposite direction and accordingly induce in the second wire temporary whirls in the same direction as the main—which correspond to similar current. See Figs. 10 and 11.

(*To be Continued*).

Commercial Experience—*Cont'd.*

C. N. JACKSON

The ready-to-serve rate afforded excellent opportunity to enable the solicitors to calculate the cost to within a small per cent. for the prospective customer. After we knew what the demand would be we could always estimate that we would make a flat price of a certain amount per month; this price was one-twelfth of the annual ready-to-serve charge. Then guessing what the current would be at 1c. was easy. Even if we did miss it 25 per cent. the error would not be a big item, and not worth a complaint from the customer. Consequently our complaints were reduced to a very small number.

We had very little trouble with customers increasing their demand without our knowledge, as every contractor in the city was trained to notify us whenever he added any new equipment. The large customers were watched by the meter inspectors and every fall and winter the inspectors would make it a point to drop in at about 4.30 P. M. and take a reading from the meter which would give the maximum demand. This was reported and if it had not increased since the rate was made nothing was done. If it had increased we would readjust the rate on a proper basis.

We were competing with artificial gas at 90c. and natural gas at 35c. As natural gas has about 900 b.t.u. per cubic foot, or about double the heat of artificial gas, the price of it was equivalent to 20c. gas, which made gas engines very popular and caused us to concentrate our energies on that competition, as it would never do to allow these engines to obtain a start.

There were two gas-engine plants in operation; one in a combined office building and theater, and one lighting a large clothing store besides furnishing light to other occupants of the building. We could not approach the latter for reasons which were rather personal, but we went after the office building and succeeded in having the gas engine removed. The plant was equipped with storage batteries and was up-to-date in every respect. It was just being installed when I took charge of the contract department. On my first visit I learned that it was guaranteed by the manufacturer, so I went to work to "knock" it if possible. Dun's report showed the manufacturer to be in hard straits, which talking point I used to the limit, arguing that repair parts would be an impossibility in case the company went out of business. When the manufacturer's expert was setting up the plant I spent a great deal of time with him, showing him our power station and other points of interest, and at the same time learned many bad points about the engine. I got on friendly terms with the engineer who was to run the plant, and he often in confidence told me he was doing too much work for the money he was receiving. I allowed him to think that way as much as he pleased, with the result of several small raises in his salary; but he was never satisfied and finally he asked once too often. The next time I saw him he was running a 15 h. p. steam engine in a small steam laundry. The gas engine would never work after this engineer left; the manufacturers had failed and the engine was paid for, so I had no trouble in securing a contract after that. The entire plant, battery and all, was sold for almost nothing. After this experience we would stop any gas engine "scares" with the above story.

(*To be Continued*).

Co-operative Commercialism in the Electrical Field—*Cont'd*

J. ROBERT CROUSE

With some exceptions, I believe that other branches could be substituted in this quotation for "Contractor," and it would have in considerable degree comparable application.

The fundamental reason for this general condition, as I see it, is the highly technical nature of the business itself. It is comparatively young and to date necessarily the product of the technician and the engineer, who for this very reason are likely to undervalue the importance of the selling and commercial branch.

As proof that the electrical business was not making satisfactory gains, I cite you a second time that the incandescent lamp business gained only 5 per cent. in 1904 over 1903; only 8 per cent. in 1905 over 1904, a notable decrease from the gains of earlier years, during which the peculiar and exclusive merits of electric service for certain classes of business were sufficient to maintain rapid increase.

At the time mentioned, in 1905, we believed as incandescent lamp makers, and we were further convinced that the electrical trade in general should also be equally interested, that the time had arrived when the old rates of gain in the business would only be secured in future as the result of very materially increased commercial activity all along the line—which is what the Co-operative Association stands for, in a word.

As to this question of wiring, treated of by your President, it is obviously the essential thing for all of us. It directly involves the whole commercial problem, for the public must first be educated to the comforts, conveniences and inherent advantages of electrical service for light, heat and power before they can be persuaded to invest their good money in the necessary wiring of old or new properties.

Along with this is the equally essential proposition that the central station shall adopt a liberal and progressive policy in the extension of their mains, and that we all lay our work out with due regard to a constantly increasing efficiency of the service, by reason of which certain classes of business not hitherto considered available will fall within our reach. I have in mind particularly the great developments in new illuminants in the lighting field.

On this great question, of interest to us all, of educating the public to the freest possible use of electrical service, we propose the following plans:

That we get together as manufacturers, jobbers and central stations and conduct a national campaign of advertising in the magazines and periodicals of the country, and arrange as well for the systematic introduction into the reading columns of timely and interesting articles on electrical development and application.

We propose also the establishment of a national electrical press bureau for the systematic dissemination to the daily press of the entire country of news articles on the subject of electrical progress and development, which will have at the same time a legitimate commercial value.

Similarly, to have this Bureau carry on the same lines of work in the thousand or more trade journals reaching as many lines of retail, wholesale and manufacturing businesses.

(*To be Continued*).

Consumers' Load Factor

C. HOLM

THE salesman for a power company or a machinery house usually meets as his first awkward question, "Well, what will my power bills average per month if I put in motors and use electricity?" This is an awkward question, because on the part of the consumer it is his deciding factor, and on the part of the salesman he cannot tell exactly what the consumer's bills are liable to amount to. Of course, the salesman's troubles are due to the fact that no two shops ever use motors the same length of time per day.

To overcome this stumbling-block a power company in one of our largest cities averaged its bills to many customers in similar lines covering a period of one year. Knowing the number of connected horse-power in each shop, it was then easy to find what percentage of the connected horse-power the consumer was actually using. This percentage, or load factor, for many lines is given below and will be found of great assistance to salesmen of power or motors.

How motors are usually sold will serve as an example of how to use the table. We shall, therefore, assume that the prospective customer has a carpenter shop and is equipped to build frame houses and do a repair business. In such a shop the following machines might be his equipment:

1 Universal saw bench	7½ H. P.
1 Turning lathe	2 H. P.
1 Grindstone	2 H. P.
1 Band saw	2 H. P.

If a motor were connected to each machine, four motors would be required with a total of 13½ horse-power. Four motors of the above ratings would cost about $325. Now, one motor of 10-horse-power rating, which would be ample if all the machines were connected to a countershaft, would cost only $210. With the motors in place and wired up, the net difference in cost between the two installations would be about $200 in favor of a short shaft and a 10-horse-power motor. It would take several years to pay this amount in the savings due to the individual drive, with the chance of its never being offset, on acount of the extra cost of repairs and attendance due to the increased number of motors. We shall, therefore, assume that one motor of 10 horse-power is selected and installed.

This shop will run 9 hours per day, five days a week, and 5 hours on Saturday.

Allowing 800 watts per horse-power, the 10-horse-power motor requires:

800 watts x 10 h. p.=8000 watts

8000 watts x 9 hours=72,000 watt-hours per full day

72,000 watt-hours x 5 days=360,000 watt-hours per five days

8000 watts x 5 hours=40,000 watt-hours per short day

which gives a total of 400,000 watt-hours per working week, or 400 k. w. hours.

400 k. w. hours x 52 weeks=20,800 k. w. hours per year as total consumption.

20,800 k. w. hours x 10 cents per k. w. hour=$2,080, cost per year with a load factor of 100 per cent.

Turning to our table we learn that small carpenter shops use on an average of 5 per cent. of connected horse-power, and so

$2,080 x .05=$104 per year, or approximately $8.67 per month.

It might be criticised that with 13½ connected horse-power the estimated cost would be higher. In reply it may be stated that the values given are the result of averaging a great many individual and group drive systems, so that 5 per cent. tends to be high for one case and low for another. It serves, however, to give a very close idea of what bills the customer may expect to meet.

In explanation of why a value of 800 watts per horse-power was used instead of 746, it may be said that the rating of a motor by the manufacturers is based on its brake horse-power at the pulley. Therefore 746 watts will give the output of the motor per horse-power; but to allow for losses in the motor a value of 800 watts per horse-power input through the customer's meter should be considered.

To allow for losses this value can be used up to 25 horse-power, after which it may be advisable to obtain the actual efficiency of the motor or motors to be installed in order to reduce the variability of the calculation.

The great majority of motor applications use from the 20 horse-power size down, so that it is seldom necessary to use exact motor efficiencies for calculation.

TABLE OF LOAD FACTORS.

Industry	Load Factor	Industry	Load Factor
Bakery	.032	Glass sign makers	.22
Bottling establishment	.1	Grocers' coffee mill	.02
Broom factory	.25	Linotypes	.4
Candy factory	.2	Machine shops	.175
Carpenter shop	.05	Newspapers	.12
Clothing manufacturing	.4	Printing presses	.25
Dye works	.22	Shirt factory	.084
Electrotyper	.09	Trunk factory	.02
Freight elevator	.1	Wooden box factory	.25
Passenger elevator	.06		

The above load factors are the averages of a great many tests extending, in most cases, over a period of one year.

Questions and Answers

QUESTIONS OF GENERAL INTEREST WILL IN FUTURE BE ANSWERED UNDER THIS HEAD.

No. 1001.—*When measuring the drop in potential between the main switch and the last lamp I found the voltage to be higher at the lamp than at the switch. This same result was secured with two voltmeters, no matter which was used to measure the voltage at the lamp and which was used to measure the voltage at the main switch.* F. H. S.

This peculiar result can be obtained with a three-wire circuit, and if the circuit you tested was three-wire the phenomenon can be easily explained, otherwise I can see no reason why such a result should be obtained. With a three-wire circuit with the load unbalanced the drop in potential in the neutral wire tends to increase the difference of potential between the main switch and last lamp on the heavily-loaded side, and to reduce the difference in potential between the main switch and last lamp on the lightly-loaded side of the system. This effect will be so great on circuits very much out of balance as to cause the result observed.

No. 1002.—*The wiring in our shop is apparently perfect. I cannot ring through it with a 10,000-ohm magneto. When I touch either wire to a ground pipe there is a spark indicating a leak, but I am not able to locate it. The shop is supplied by the lighting company. We have our own transformer. The voltage is 220 volts and the frequency is 60 cycles.* IGNORAMUS.

Do not try that again. You may burn out the transformer by grounding one side of an alternating system. If the 10,000-ohm magneto does not ring through your wiring, the wiring is in good condition. The spark you see when you ground one side of the system is due to the capacity of the line and will appear no matter how perfect the insulation. The line has a definite capacity to ground depending on the distance from the wires to the nearest conducting surface. This capacity permits a charging current to flow the same as if there was a direct connection between the wires and ground.

No. 1003.—*In testing the insulation resistance of a wiring system with a wheatstone bridge I do not get the same resistance with a steady deflection of the galvanometer than I get with a momentary deflection. Please let me know if there is any reason for this, or is there something wrong with the bridge.* A WIREMAN.

Do not test insulation resistance with a wheatstone bridge. Follow the instructions under the head of direct-deflection method of measuring resistance. The reading you obtain with a steady deflection of the galvanometer is the one which is more nearly correct, though the result is not so accurate as that obtained with the same instrument using the direct deflection method. The reason you obtain an entirely different reading when the deflection is momentary is due to the charging current; see No. 1002. This current flows for an instant charging the conductors of the system and ceases after the system is charged to full potential.

No. 1004.—*We have been operating 2200-volt circuits with knife switches, but during the past month they are so severely that our operator is afraid to open them. These switches were supplied by a large manufacturer who said they would be all right for this voltage.* SUPERINTENDENT.

Knife switches will operate satisfactorily on 2200 volts with an incandescent lamp load provided the switches were made for this purpose, as you say. The trouble is probably due to your adding a motor load or arc lamps during the past month. Motors and arc lamps have a lower power factor than incandescent lamps and the low power factor causes severe arcing.

Review of the Technical Press

House Cleaning by Electricity

[*Bulletin of the New York Edison Co., Sept.,* 1907.]

An interesting application of electricity is given; the particular machine mentioned is made by the Electric Renovator Manufacturing Company, of Pittsburgh. The machine is portable and resembles an ordinary carpet sweeper in general appearance.

Electric Lighting of a Colonial Cottage

JOSEPH INSULL.

[*The Illuminating Engineer, Sept.,* 1907.]

This is a well-illustrated article showing up-to-date methods for lighting a cottage of the colonial type. Holophane glass globes are used to a large extent.

Synchronizing

PAUL MACGAHAN AND H. W. YOUNG.

[*The Electric Journal, Sept.,* 1907.]

Different methods of synchronizing are described with especial reference to the different types of sychronizing devices now on the market.

The Elevator Industry

CHARLES H. KLOMAN.

[*Cassier's Magazine, London, Sept.,* 1907.]

This is a very well-illustrated article covering the subject of the elevator industry in America. Examples are given of the elevator construction in different large office buildings and hotels. The article is largely historical.

Heating and Ventilation of Machine Shops

CHAS. L. HUBBARD.

[*Machinery, Sept.,* 1907.]

Among the methods of heating machine shops, the author considers the heating by hot air as most satisfactory. Diagrams show sample layouts with the hot-air pipes, fans and heaters in plan and elevation.

Hydro-Electric Power Development

WILLIAM KENNEDY.

[*The Canadian Electrical News, September,* 1907.]

An article giving the advances which have been made in the design of hydraulic turbines during recent years.

Electrification on the Southern Pacific

[*Railroad Gazette, September 6, 1907.*]

An editorial dealing with the electrification of the Southern Pacific Railroad between Rockland, Cal., and Sparks, Nev., 135 miles over the Sierra Nevada Mountains, mentions this electrification as the most difficult and important installation which has so far been seriously considered. The statement is made that the economy of electric operation is still open to some discussion, though the possibility of increasing the carrying capacity of a given piece of track by substituting electricity for steam as motive power is more easily proved. The important problem in the case of the electrification of the Southern Pacific is what method to adopt to increase the carrying capacity of this portion of the line, and economy of operation is of secondary importance. The traffic is heavy, but quite irregular, and blockades are frequent at both ends of the division. The road is single track, with few sidings, and because of difficult location it is practically impossible to double track the road or to greatly increase the length of the sidings.

Some of the difficulties to be overcome if electric operation of the entire division is finally decided upon, are installation and maintenance of transmission lines to withstand heavy snows and violent storms, provision for wide variations in load with heavy but intermittent traffic, danger from fire in snow sheds during the summer and from short circuits due to melting snow in the spring, cost of a substantial and permanent overhead line construction and danger to trainmen in tunnels and snow sheds, if this method should be employed and interference by snow in the open if the third-rail construction is used. The report of Allen H. Babcock, the electrical engineer of the Southern Pacific, and Frank J. Sprague, who has been retained as consulting engineer, is awaited with great interest by railroad men.

Live Rail Accidents in England

[*The Railroad Gazette, September, 13, 1907.*]

English electrical experts are quiet again just now, but the danger of the live rail between tracks was one of their strong arguments in favor of the single-phase alternating-current system. The statistics that have been officially compiled of the live-rail fatalities during 1906 will not help them in that argument, whatever may be the relative merits of the two systems on other grounds.

Kimball Concrete Steel Ties

[*The Railway Age, September 20, 1907.*]

A type of concrete-steel tie which gives promise of solving the troublesome tie problem satisfactorily is one which is now being subjected to the test of heavy traffic in the tracks of the Chicago & Alton and the Pere Marquette.

The tie is patented by George H. Kimball, consulting engineer, Detroit, Mich.

Pay As You Enter Cars

[*Electric Railway Review, September 21, 1907.*]

During the past three years a type of car and method of collection have been perfected and adopted in Montreal, Can., known as the "pay-as-you-enter" car system. The result secured from the operation of this system, principally in the reduced number of accidents, has been such as to attract the attention and investigation of many of the more prominent and progressive street railway managers, with the result that cars of this type are now under construction for use in New York, Buffalo, Cleveland and Detroit.

Magnetic Field due to an Electric Current in a Straight Wire

W. J. HUMPHREYS.

[*Science, September 27, 1907.*]

Let electrons, all moving in the same direction with the constant velocity V centimeters per second, be uniformly distributed along a straight wire, and let E be the total amount of electricity per centimeter length of the wire. Then, assuming the field of force from each electron to be the same in all directions, that is, moving slowly and undisturbed by other electrons, the rate of change of induction, due to the electricity at all parts of the wire, through a circle at right angles to it of radius a; or in other words, the work required to carry a unit magnetic pole once around this circle is given by the equation

$$\frac{dF}{dt} = 2\int_0^{\text{inf.}} \frac{Edl}{r^2} 2\pi a V \cos\Phi$$

But $\cos\Phi dl = rd\Phi$, $1/r = \cos\Phi/a$, and $EV = C$, the current.

Hence

$$\frac{dF}{dt} = 4\pi C \int_0^{\frac{\pi}{2}} \cos\Phi d\Phi = 4\pi C,$$

and therefore the force on a unit pole at any point on the circumference of a circle of radius a is ....

$$\frac{4\pi C}{2\pi a} = \frac{2C}{a}.$$

However, presumably the field due to each electron is influenced by all others, and so influenced that it is confined to a plane at right angles to the wire, but equal in every direction from it. From this it follows at once that

$$\frac{dF}{dt} = 4\pi EV = 4\pi C,$$

and

$$f = \frac{4\pi C}{2\pi a} = \frac{2C}{a}.$$

According to this conception, which I believe to be the correct one, the magnetic force at any point is due entirely to that part of the current nearest to this point; the more distant parts having no direct effect whatever. But, of course, as just explained, all electrons produce their full effects indirectly by compressing each other's fields into planes at right angles to the wire.

Tension and Sag in Span Wires

[*Electrical World, September 28, 1907.*]

HAROLD PENDER.

A mathematical treatment of the subject which engineers engaged in wire and cable work should have at hand.

Direct Current and Single Phase Railway

[*Street Railway Journal, September 28, 1907.*]

Sections and elevation of one of the railway motors are shown, also curves of performance and details of the pantagraph collectors are shown by line cuts.

The Rise of the Electric Railway

BION J. ARNOLD.

[*Western Electrician, September 28, 1907.*]

An historical article dealing with electric railway development. He states that the first extensive application of the electric motor to the propulsion of electric cars, and the one which probably gave the greatest impetus to the remarkable development which followed, was made by an American (Sprague) in 1887.

Following the successful operation of the Richmond road came a most rapid conversion from animal power to electric power of street railways of the principal cities of the country, so that by the year 1895 it might be said that almost every city of any magnitude of the United States and many of the principal cities of the world were equipped with electrically propelled cars.

Catalogue Review

The Jeffrey Mfg. Co. send catalogue No. 69A describing Jeffrey screens. Screens are shown for every purpose and of all sizes of mesh. The half-tone illustrations are very plain and line-cuts give outlines of different machines; different types of coal chutes are shown. Other illustrations show conveying and elevating machinery for all purposes, including a rubber-belt conveyor handling stone, an endless pan conveyor handling run-of-mine coal and elevators for stone and ore, also crushing machines, grab buckets and mining machinery.

A complete line of turbine pumps is listed by the Watson-Stillman Company in catalogue No. 72. An application is given of an alternating electric motor to the operation of a single-stage twinvolute turbine pump, and of a direct-current motor to a two-stage twinvolute turbine pump. A simple tank switch is illustrated and its operation is shown by diagram connections. A line cut shows the vertical submerged centrifugal pump operated by a vertical motor. Numerous tables are given.

Graphite for the month of September contains the continued article on "Pressure Reducing Valves," by William H. Wakeman; the first portion of "Power Transmission by Manila Fibre Rope," by George P. Hutchins, and interesting applications of graphite to lubrication.

Complete data regarding "Tobin Bronze" is supplied by the Ansonia Brass & Copper Company. This data includes tensile strength, specific gravity, weight per cubic inch, acid tests, crushing strength and other information all of value to the manufacturer. The applications are largely devoted to boats of different forms.

The September number of *The Steam Shovel News* has been received. This is an interesting monthly paper devoted to recent work with steam shovels.

The September number of *Paistery* gives late forms of fuse cutouts, switches and receptacles as manufactured by the H. T. Paiste Co.

About 90 pages of testimonials have been received from the Buckeye Engine Company in reference to the Buckeye Electric Blue Printing Machine. Judging from these testimonials, the Blue Printing Machine is doing good work.

The September number of *Holophane* has been received. This gives several applications of the well-known Holophane globes and reflectors.

Bulletins Nos. 1098 and 1100 have been received from The Fort Wayne Electric Works. The first of these bulletins is devoted to direct-current generators for light and power service of the belted type. Several details of construction are shown. The second bulletin is devoted to small direct-current motors. In this last bulletin applications are given of these motors to the driving of a drill press and to the driving of a pump.

The Emerson Electric Manufacturing Co. send bulletin No. 3504 describing electric exhaust fans for alternating and direct currents.

The Pittsburgh Transformer Company send a folder the major portion of which is taken up by a letter describing how a 30-light Pittsburgh transformer was struck twice during August, 1906, and continued to operate until May, 1907.

The De La Vergne vertical oil engine has recently been placed on the market by the De La Vergne Machine Company. Like their Hornsby-Akroyd horizontal oil engine which they continue to build in sizes from 13 to 250 b. h. p., the De La Vergne engine is especially designed to be operated by cheap oils, such as kerosene or fuel oil. No carburetor or valve motion is used, making this engine one of the simplest ever devised. At the present time the 7½ and 15-b. h. p. sizes only are ready for delivery. Other sizes are in construction.

The Gold Car Heating & Lighting Company give the latest methods of regulating the temperature of railway cars in a catalogue recently received. This regulator is claimed to be compact with neat appearance and to give excellent results.

"The Curtis Steam Turbine-Generator" is the title of a large pamphlet, No. 4531, issued by the General Electric Company, Schenectady, N. Y., that is perhaps the most complete and handsome publication ever sent out by any turbine manufacturer. The printing and general style of the pamphlet is very attractive, but will be found of special interest to engineers on account of the information given with regard to superheat, vacuum, economy, etc., and the détails of construction and operation of all parts of the Curtis apparatus.

Under the heading of "Economy," detailed tests are given of 9000-kw., 5000-kw., 2250-kw. and 1000-kw. turbines, which show some very remarkably high efficiencies. The advance made by this type of turbine is illustrated by the maker's claim that nearly 1,000,000 kw. of Curtis steam-turbine generators have been sold. Special attention is called to the flat efficiency curve giving high efficiency at overloads and light loads, the simplicity of design, the low maintenace, the economy in space, etc.

This publication seems to be typical of the recent desire to have such information written by and to engineers, and the following synopsis of its contents will show the wide field covered: Advantage of vertical-shaft type, economy of space, building materials and steam clearances, flow of steam, balance, lubrication, the construction of buckets, governors, foundation, low-pressure turbines, vacuum, regulation, parallel operation, ventilation, economy, etc.

Of the illustrations, the following may be taken as having special interest: Those showing the interior of the Fisk Street Station at Chicago and cross sectional view of 9000-kw. turbine, the method of cutting and riveting buckets, the hydraulic governor, low-pressure turbine sets installed and economy curves.

"Electric Heating and Cooking Devices for Marine Use," is the title of a handsome publication just issued by the General Electric Company as bulletin No. 4523. The pamphlet is bound in a neat cover and contains illustrated descriptions of small apparatus particularly useful in ships' galleys, staterooms, smoking-rooms, sick bays, etc.

A ship's lighting plant, usually of more than ample capacity for intermittent load, offers at once an available source of supply, which, utilized for cooking, heating, etc., would provide numerous real and profitable conveniences with small increase in cost.

The electric heater on account of its compactness, neatness, easy regulation and simplicity is ideal for stateroom use. The General Electric Company manufactures several forms, including luminous radiators and non-luminous air heaters. One or two-quart water heaters, electric wash bowls and electric shaving mugs are familiar conveniences and electric flat irons in sizes from 3 to 24 pounds are supplied for the laundry. Among special devices particularly serviceable on ship-board may be mentioned electric soldering irons, glue pots, curling-iron heaters, surgeon instrument sterilizers, heating pads, cigar lighters, etc.

Two distinct forms of heating elements are used by the General Electric Company, known as the cartridge and quartz enamel units. Both heating units are practically infusible and indestructible, but can be readily replaced if damaged by accident. The makers have taken great care in the design to insure the most efficient application of the heat and sufficient radiating surface so that nearly all the apparatus may be left in circuit indefinitely without fear of burn-out.

Trade Notes

The Jones & Laughlin Steel Company is a recent purchaser of additional heavy Allis-Chalmers electrical machines in the shape of two 1000-kw. 6600-volt generators wound for 25 cycles, three-phase, and designed to operate at 94 r. p. m. These units, together with a 600-kw. direct-current generator, 240 volts and operating at 110 r. p. m., will be installed in the new Aliquippa Works, situated on the Ohio River several miles outside of the city of Pittsburg.

A new 500-kw. motor generator set, comprising a synchronous motor rated at 6600 volts, wound for three-phase, 25 cycles, and a 250-volt direct-current generator is also being added to the structural shop to carry a portion of the steel mill load.

The Cuba Railway Company, with headquarters in New York City, recently purchased a No. 4 "K" Gates' Crushing Plant built by Allis-Chalmers Company for use at Canaguey, Cuba. This machine will be mounted on masonry foundation and fitted with smooth head and concaves. The product to be crushed is limestone reduced to 2½-in. product.

It is expected that this plant will be used successively on the several divisions of the road situated, in each instance, between the quarry and the right of way, parallel to which boilers, bins and crushers are arranged so that the product may be readily dumped into cars for distribution along the line.

The new power stations of the North Shore Electric Co., at Waukeegan and Blue Island, near Chicago, are furnished with alternating current electric Northern Cranes, furnished by the Northern Engineering Works, of Detroit, Mich. These cranes are 30 tons and 25 tons capacity, respectively, 58 ft. and 39 ft. span. The larger crane is equipped with an auxiliary high-speed alternating-current hoist.

The Black Hills Traction Co. have recently installed an 8-ton, 32-ft. span Northern Traveling Crane at Spearfish, S. Dak.

On Oct. 1st, Percy H. Thomas leaves the Wesitnghouse interests to join with N. J. Neall, consulting engineer of Boston, to form the firm of Thomas and Neall, electrical engineers, with offices in New York and Boston. The firm expects to do general consulting work in electrical engineering, giving special attention to high-tension transmission design, to the investigation of the difficulties in operation on high-voltage plants, to lightning protection and to extra high-tension practice. While connected with the Westinghouse Electric and Mfg. Co., Mr. Thomas and also Mr. Neall did a large amount of investigation work on high-tension problems both experimental and in commercial systems.

Mr. Thomas graduated from the Massachusetts Institute of Technology, and entered the employ of the Westinghouse Electric and Mfg. Co. as a "student." His early work was on insulation of apparatus and on transformers, followed by a stay in Brazil in 1896-7 in connection with one of the early transmission plants. Later he spent some years in the investigation of static disturbances and lightning, with special reference to the protection of commercial systems. Later, as chief electrician of the Cooper Hewitt Elect. Co., he carried on the practical development of the Cooper Hewitt Mercury vapor apparatus. He has for some time been much interested in the American Institute of Electrical Engineers, before which institute he has read a number of papers.

Mr. Neall, who is also a graduate of the Massachusetts Institute of Technology and has made a specialty of high-tension work, has been practising his profession in Boston, where he opened his office in the spring of 1906.

Mr. Harry De Steese, of New York City, has recently been appointed by the International Timber Preserving Co., of Chicago, manufacturers of the public-service timber preserver, "Neosote," as eastern representative. For sixteen years Mr. De Steese has been constantly identified with various branches of the public-service work, both in this country and in Europe. His earliest experience was gained under Postmaster-General Payne at Milwaukee, and from 1896 to 1900 he was manager of the railway department of the Western Electric Co., of New York, leaving that position to take charge of the establishment of a supply business in London, England. Mr. De Steese's friends will be glad to learn that his new connection, and the International Timber Preserving Co. is to be congratulated on having secured so able and energetic a representative.

Eugene Munsell & Company, the well-known dealers in mica, and the Mica Insulator Company, manufacturers of micanite and other high-grade electrical insulators, for many years located at No. 218 Water Street, New York, have removed to No. 68 Church Street, corner of Vesey Street.

Owing to the increase in their business, they were compelled to seek more commodious quarters, and their new location is one of the most central in the down-town business district, being only one block west of Broadway, and within five minutes' walk of the principal railways and ferries. They occupy four floors at their new location, the second floor being devoted entirely to their offices, while the other three are used for stock and shipping departments, for the preparation and assorting of mica and for the manufacture of mica specialties.

A motion for preliminary injunction was brought in the United States Circuit Court for the Middle District of Tennessee by the General Electric Company against the city of Nashville, Tenn., to restrain the city from the further use of some alternating-current generators manufactured by the Bullock Electric Manufacturing Company, of Cincinnati, O. These generators have laminated pole pieces attached to the revolving field spider by means of bolts from the spider engaging a transverse bar imbedded in the pole piece, a construction covered by the Parcelle Patent No. 463,704, granted November 24, 1891, which has been heretofore sustained by the courts.

The Bristol Company are about to erect another new addition to their present plant. This addition is to be 53x170 ft., three stories high.

The additional space is made necessary by the increased demand for "Bristol's" Recorders and "Bristol's" Patent Steel Belt Lacing. With the amount of business they already have in sight, it will not be long before even this addition will be crowded.

Errata

Two typographical errors appear in the September issue. The value of F on page 348, second column, should be $F = \frac{lW}{(kE)^2}$, and the value of b on page 349, first column, should be $b = 2\pi f C$.

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The Westinghouse Companies

THE whole business world was startled on October 23d by applications for a receivership for the great Westinghouse Electric & Mfg. Company, and for the Westinghouse Machine Co. Investigations made by the receivers appointed show very clearly that the cause of the trouble was not a falling-off in business, but was brought about by the state of the money market, making it expedient for those interested to ask for the appointment of receivers. The unusual number of orders requiring large outlays for materials, and the constant drain of the pay-roll, without any immediate returns because of the long time required before completion and payment, at a time of unusual financial stringency, anticipated the difficulty. Such orders for machinery covered work which must extend over a period of months and sometimes years before realization on investment, and therefore required borrowed capital. The great stringency of the money market prevented the renewal of the customary sources of ready money, and therefore made necessary prompt action to conserve the interests of the stockholders, creditors and all concerned. That the action was wise and timely is the consensus of opinion of the most conservative financial men in the country. There is no question that the various properties will be returned to the stockholders unimpaired in value as soon as the money market regains its equilibrium.

The splendid organizations of the different companies will be preserved to receive and execute orders with the same satisfaction to the customer as heretofore. There has not been even a momentary pause in the operations of the works, and orders are being filled with dispatch.

So much confidence is felt in the men appointed as receivers for the several companies affected that the future success of these interests promises to be as marked as in the past.

In a formal statement issued by George Westinghouse it appears that both the Electric Company and the Machine Company are solvent and are doing the largest and most satisfactory business in their history. Each company is earning liberal dividends on its stock and has quick assets substantially equal to its liabilities. It is understood that there will be no changes in the personnel of the companies, nor in the general policy which has hitherto been followed in the conduct of business. In short, the appointment of receivers was merely a legal step brought about by reasons given above, which in no wise affect the company in manufacturing and selling, and in no degree affect the cordial relations existing between the companies and their respective customers.

The public press has been outspoken in its sincere regret that there should have been any temporary embarrassment to George Westinghouse and his important industrial companies. The *New York Times* says: "He has done so much for the splendid industrial evolution of the country, his enterprises have been so varied and so important, he has carried the name and the fame of American invention and development in the application of novel scientific principles over such wide areas and everywhere has won for his nation such admiration, confidence and respect, that he presents himself, in a way, as an American institution in whom we have patriotic pride. The wish will be universal and the belief general that he will come through the difficulties he has encountered safely with his material and intellectual resources undiminished, and ready for new triumphs."

The general and broad faith which is felt in the personality of George Westinghouse and his companies is certain to relieve the financial situation of these solvent and magnificent organizations. The *Boston Herald* says:

"This undaunted man will surely emerge triumphant from the predicament in which the financial disturbances culminating this week have placed him and several of the great industrial companies of which he is the illustrious and honored head. George Westinghouse is a man who knows no fear, and always conquers. He is not a speculator, not a 'Napoleon of Finance,' not a dreamer of dreams, but a great inventor and a great manufacturer, known the world over, and carrying the American courage and foresight and enterprise into every country on the globe. He has, by sheer grit and the genius of enlightened persistence, built up some of the most important industries of our time. He is one of the most commanding figures in the engineering world, honored everywhere for his integrity no less than for his achievements. In his employ, both in America and Europe, are many thousands of men; in his industries many millions of capital. No successful man of this era cares less for the personal acquisition of money than he, few care so little for it. He has never sought to gather wealth for its own sake. Money is to him but an instrument which, used with brains, makes industry grow. Years ago he might have retired with vast wealth. But work, not ease, is his delight. To him, perhaps more than to any other individual, is due much of the wondrous progress in transportation, and in the commercial application of electricity. Any serious reverse to a man of this character and force would partake of the nature of a public calamity. But he will not permit the present difficulty to seriously retard him. He will go on. It may truly be said of him that he has long been a creator of wealth, a discoverer of opportunity, a powerful influence in the advance of the age. In all lands men will rejoice, for his sake as well as for their own, that his industrial organizations are solvent, and everywhere there is hope that he will be spared for many more years of superb achievement by which armies of labor benefit and the whole body of civilization is aided in its onward march."

Application of the Oscillograph

IT was in 1904 at St. Louis before the International Congress of Electrical Engineers that Blondel, the eminent French physicist, directed the attention of American engineers to the value of the oscillograph in the study of alternating-circuit conditions. Very little use of the device has yet been made except by the larger electrical manufacturers and the New York testing laboratories. The description of the method of working and the experimental use of the oscillograph as found at another page are suggestive of possibilities.

Some four years ago an attempt to run three 150-kw. gas-engine driven alternators in parallel occasioned six months' experimental study on the part of three men who worked by the usual cut-and-try methods. Two of the gas engines would run very well together, but any third engine made trouble. Here was a problem which prevented a particular manufacturer from pushing the sale of gas-engine plants of this character and seemingly warrented the heavy expense entailed by try-again methods of paralleling. The damage to the machines by such methods of working were insignificant in comparison with the commercial prize. To the credit of the manufacturer be it said that it was finally solved. While the case is unusual, it is typical of a wide variety of operating problems which would yield to oscillograph work.

Another class of problems is the study of wave surges in transmission circuits. We know the causes of many of its phenomena owing to the frequency with which they occur and the resultant damage which they cause. Thus an eminent scientist on several occasions has measured these over-waves by their wreckage, following a method of calculation which few have the patience to master, and fewer still the opportunity to use.

Moreover, the method is only applicable in the study of wrecked or damaged systems and may hardly be dignified into a method of wave study.

The real study of the surge problem ought to begin experimentally.

It is possible to measure the surge following a simple switching operation not only at the station, but at measured lengths from the disturbance center; and thus it should be actually easy to get at the logarithmic decrement of such a wave crest and to define its sphere of disturbance.

By an extended study of the operating system per se, it would be possible to measure its over-waves and to protect it at the proper points. Any other method of attacking line problems is wasteful and dangerous to property. We may look for a rational plan of lightning protection only after the ground-work has been laid by the oscillograph.

Starting Rotary Converters as Induction Motors

THE avoidance of auxiliary apparatus in the starting of rotary converters is a step in the right direction, in so far as it leads to a simplification of the system. The starting of rotary converters as induction motors is ideal in method since the primary source of power is alternating current, which is always available regardless of what may be the condition of auxiliary apparatus in the substation; also this method eliminates synchronizing with its attendant difficulties of equalizing the converter voltage with a fluctuating voltage of supply. Some engineers find the starting current objectionable when this method of starting is employed; which fact leads us to make a few observations pertinent to this subject even though they concern a question of design.

An induction motor or a rotary converter can be made to give a high starting torque, when the secondary circuits of the one or the dampers of the other are of low resistance. This is done by reducing the radial length of air gap and by increasing its active area. An increase in resistance of an induction motor secondary or an increase in resistance of the dampers on a rotary converter, without other changes in either machine, has the effect of causing the maximum torque to occur at a lower speed.

The reduction of the length of radial air gap and the increase of the amount of iron at the air gap, without changing the resistance, results in an increase of maximum torque and causes this maximum torque to occur at lower speed, at standstill if required.

The amount of current drawn from the line for starting machines as induction motors, when the resistance of the secondary or dampers is low, will be so large as to cause a considerable voltage drop in the line. The drop in voltage is avoided by starting these machines at a lower voltage than normal.

A short radial length and a large area of air gap, besides increasing the starting torque, reduce the tendency to hunt. Rotary converters thus made are therefore frequently not provided with dampers or the dampers are of high resistance, since low resistance dampers are unnecessary.

Pole Line Wiring

WIRES transmitting an alternating current have a back electromotive force induced in them by the alternating magnetic field produced by the current. This induced electromotive force tends to diminish the voltage at the transformer supplying the customer, and may bring it to a value insufficient for good light and power. Dissatisfaction with the service is often thereby created.

The amount of the induced electromotive force depends on the distance between the wires, on the amount of current transmitted and on the frequency of the circuit. With a given size of wire the amount of the induced electromotive force can be reduced, that is, the voltage regulation of the line can be improved: first, by erecting the wires of any one feeder close together; second, by neutralizing the field of one feeder with the field of another feeder of similar capacity; third, by reducing the amount of current, or fourth, by reducing the frequency of alternation.

Crossarms are made with a standard spacing between pins, thus limiting the distance between wires to a minimum when the wires are erected on adjacent pins. This distance cannot safely be reduced by means of crossarms with a special spacing between pins, owing to the danger of the wires swinging and coming into contact each with another.

More than one crossarm is usually installed on one pole. By placing wires connected to opposite terminals of the generator one above the other on the several arms, the magnetic field produced by each of two feeders is partially neutralized by the other feeder. The magnetic field is entirely neutralized when the wires of opposite polarity are close together and the current in each is of the same amount.

While the voltage per phase is fixed by the station apparatus, and feeder connections are usually made in delta, it is possible to reduce the current per feeder by rearranging the connections of the generator windings when they are supplied with six terminals; that is, the generator windings can be connected in star instead of in delta, which gives a higher voltage between wires and a lower current per feeder. This procedure is not advisable for small stations owing to the necessity of running a fourth wire or grounding the neutral connection, though it is sometimes necessary in order to secure satisfactory line regulation. Transformers adapted to the higher voltage must be installed when this change is made.

The current per feeder can also be reduced by increasing the number of feeders. Advantage can be taken of this fact by transmitting large amounts of power over more than one feeder, the inductive drop in voltage being reduced in a greater ratio than the increase in number of feeders, provided the feeders be so placed that the negative direction of magnetic field produced by current in one is opposed by a positive direction of field in that next adjacent.

The frequency of the alternating current is fixed by the station apparatus, and must be maintained for the transformers, motors and lights at the end of the line; a large investment in new apparatus is therefore required for changing the frequency of the station. Two frequencies are now standard with light and power stations, namely, 25 cycles and 60 cycles per second, the lower frequency giving the better service for operating motors and for conversion of alternating current to direct current, while the higher frequency, 60 cycles, is greatly better for operating incandescent lamps and will operate arc lamps. Where the lighting equipment is a considerable item, a lower frequency than 60 cycles is inadvisable unless the density of service warrants conversion to direct current.

In addition to the voltage induced in the line by the current transmitted, a voltage may be induced in adjacent feeders or circuits so as to cause a considerable wattage loss and a consequent reduction of voltage in the line. One instance was encountered where the primary drop in potential was much in excess of the calculated amount. On examination, a length was found where the two wires of the feeder had been installed on the outermost pins of the crossarms and the supply and return of a direct-current series arc circuit were on the inside pins. By placing the wires of the direct-current arc circuit on two pins on one side of the pole and the wires transmitting the alternating current on two pins on the opposite side of the pole, the primary drop in potential was reduced to 25 per cent. of its former amount. Evidently the direct-current arc circuit had been acting in a manner similar to a transformer secondary, by taking power from the primary line. This was attested by the fact that the reduction in voltage loss obtained by transposing the wires was greater than would have been obtained by this transposition if the arc circuit had not been there.

Some misunderstanding has arisen regarding the advisability of transposing lines carrying an alternating current. The object in transposing the wires is to reduce the effect on neighboring circuits; transposition does not reduce inductive drop in potential due to the current transmitted, as is frequently the supposition. Where the only circuits affected are telephone circuits belonging to the light and power company owning the transmission line, transposition of the telephone circuit will usually give as good results as transposition of the transmission line.

Aside from the advantages to be obtained by the placing of transmission wires properly the method of supporting the wires is of great importance. The customary pole line of eastern stations consists of chestnut poles 35 ft. long, seven inches diameter at top and 12 in. diameter six feet from the butt; at corners these dimensions are increased to eight inches top and 14 in. butt. The taper of the poles depends on the location of the trees before cutting. In dense woods the trees grow with less taper than in the open; different poles in any one lot having different degrees of taper.

The poles should be approximately straight. Tops are usually pointed and painted; the painted top sheds water from the pole and conduces to a long pole life. All poles must be thoroughly seasoned before erection. It is advisable to coat the pole butts with tar, filling all cracks and interstices to prevent the entrance of moisture. Creosoted poles have a long life, but difficulties of transportation preclude treatment with creosote except near large cities, while tar is readily applied. The tar or creosote must be applied so as to be well above the ground level when the poles are set in final condition. Gains for crossarms are most conveniently cut before erecting the poles, also holes must be bored for securing crossarms to poles. One hole should be bored at each gain for a through-bolt through crossarm and pole. Some difficulty is experienced in matching holes in crossarms and poles when two bolts are used for securing crossarms; one through-bolt and two lag screws are more conveniently placed in position.

Corner poles and all poles at changes in direction of line are secured by guy wires and anchors. Any of the patent guy anchors obtained from supply houses makes a good anchorage, though obstructions do not always permit of their use. Where obstructions prevent the extension of a guy wire to an anchorage in the ground, a half pole may be set ten feet or more away from the line pole and deep in the ground, the guy wire being attached to the top of the half pole. In some instances it is found impossible to place more than one pole at corners and the available space does not permit of guy wires. Here a timber work of 10-ft. timbers can advantageously be arranged about the pole base, two pairs of timbers being buried with upper sides at the ground surface, one of each pair being placed on either side of the pole and the pairs laid at right angles to each other. This construction, with a 40-ft. pole sunk 10 ft. in the ground, makes a secure anchorage for corner pole.

The condition of ground influences the depth to set the pole; five feet is sufficient for average hard ground. Where the ground is sandy this distance is increased to six feet. In damp, marshy ground broken stone is placed around the pole base, often in a barrel previously sunk in the hole. The pole is securely guyed.

The primary object of the poles is to support the wires, and they should perform this function without the addition of numerous guy wires. The guy wires are for the purpose of safeguarding the poles against side stresses; the poles should stand of themselves without assistance.

Crossarms of well-seasoned yellow pine, unpainted, give good service. Some difficulty is experienced in obtaining this wood of a straight grain and without knots, and in order to obtain the best wood it should be selected stock, free from all defects. Crossarms may be obtained bored ready for pins and for crossarm braces. The upper corners are rounded to prevent splintering.

Two strap-iron crossarm braces are secured to the pole by one lag screw at the pole center and one lag screw or bolt on each side of the crossarm. Crossarms are advisably placed in position while the poles are down, though care must be taken to prevent detaching of or breaking them while setting the pole. They are set facing on alternating poles, the tension of the line being against the pole for one-half the number of crossarms. At corners and anchors the crossarms are set so that the tension on those mounted on the three poles next to the corner is against the pole, that is, these crossarms are on the side of the pole nearest the corner or anchor. Double crossarms had best be placed on corner poles for taking the strain due to change in direction of tension. A good right-angle turn is made by erecting double crossarms at 45 degrees to the line, and placing the wires on the side of the insulators to pull against the insulators, the tie wires simply holding the transmission wires in place. Wires on straight runs are alternately placed on inside and outside of insulators.

Pins are made from white oak or locust wood, well seasoned and often kiln dried. They are frequently creosoted, as this treatment has some effect in preventing the leakage current from assuming a large figure and also, owing to their size, this treatment is readily applied.

Glass insulators are usually used for 1000 and 2000 volt lines; the deep-groove, double-petticoat type being adapted to this work. There is a tendency to use telephone insulators for these voltages, breakdowns in the line at times occurring when these insulators are used, the breakdowns being caused by arcing across the insulator to the pin in wet weather. Telephone insulators are not designed for this work and should not be used.

Tie wires are cut from the transmission wires, the insulation on the tie wires reducing the leakage current and preventing injury to the insulation of the feeder that might be caused by the sharp turns of bare wire.

Triple-braided weatherproof wire, as now made, gives effective results at 1000 and 2000 volts. In nearly every sample of wire examined the braid was found to be thoroughly impregnated with moisture repellent and was found in good condition after continued service. While this insulation has frequently been criticized as inadequate, it is effective in preventing short circuits where the wires occasionally swing together and would produce a short circuit if they were not insulated.

Wires smaller than No. 8 B. & S. are not erected on poles on account of the strength of the wires not being sufficient to hold the weight of insulation in addition to the weight of the copper under the conditions encountered in service. In order to limit the tension on this wire it is customary to place the poles with spans not more than 110 ft. Where necessary, spans of No. 8 wire have been made as much as 200 ft., though the sag is so great that the wires swing excessively. Spans are reduced to 70 ft. from the corner pole to the next pole to minimize the strain on the poles. Longer spans can be made with bare wire than with insulated wire with the same sag and tension, since the bare wire is not required to support the weight of insulation.

The limit for size of wire on 60-cycle systems is best kept below No. 0000 B. & S., as with wire above this size the skin effect becomes appreciable. The best mechanical results are obtained with wire not larger than No. 0 B. & S., unless insulators, especially designed for heavy wire, are erected. Short lengths of No. 0000 B. & S. wire can be installed on deep groove glass insulators, though the strain due to the weight of this size of wire is such that it is usually best to divide these feeders between two or more, particularly as the inductive effects are also thereby reduced.

Wiring Underground

As the density of business increases, the wiring required for transmitting the power increases also, and to such an amount that pole-line wiring becomes unsatisfactory in service. Numerous overhead wires are continually coming into contact with each other, and in populous districts they interfere with the handling of fires. Approximately the limit to overhead wiring is 24 connections per pole, a greater number producing stresses on the pole-line so great as to endanger their breaking down, especially during strong windstorms or when they carry an excessive amount of snow or sleet.

The cost for excavating streets and repaving them is approximately the same whether one or more ducts are laid. This cost, figured on the basis of cost per duct, diminishes as the number of ducts is increased until, with all things considered, 24 individual wires will be found to be cheapest installed under ground.

Where the streets are paved the width of trench must be kept as narrow as possible, shoring being used to hold the sides during process of excavation. A depth of four feet to top of ducts is usual. The nature of the ground influences the method of protecting the duct and the type of conduit to be installed.

Vitrified tile ducts are supplied in short lengths and give good service on hard ground; with soft ground, however, and where the ground sinks from time to time, it is better to install the longest length of tile ducts or the individual ducts of treated wood, stone or a compound especially prepared for this purpose.

In laying tile ducts on any but the very hardest ground a layer of concrete, approximately four inches thick, is placed at the bottom of the ditch, then the ducts are centered by dowel-pins and laid on this foundation. Tarred paper is wrapped around the joints between sections to prevent the entrance of cement or other foreign matter which might do injury to the cables. Other conduits are laid on top of those first laid, with joints at intermediate points, the layers being covered with cement. Approximately three inches of concrete is placed at each side of the conduit and a covering of four inches of concrete is placed over the top. The whole conduit system thus forms a solid masonry structure continuous from manhole to manhole. The conduit is given a slight pitch toward the ends for the purpose of draining out any moisture which may accumulate. Where cables of large size are inserted in the conduit, numerous empty ducts should be provided not only for the purpose of additions as required at any time, but also for the purpose of ventilation. The relative merits of round or square holes is now an undecided question; the square hole does not require as much tile for a given number of cable openings as does the round hole, and the opening is larger, giving more air-space about the cable. There are those who claim these advantages are offset by the increased ease of pulling cable in round ducts.

Individual ducts, whether stone, treated wood or compound, are laid on a foundation of concrete and the spaces between them are filled with cement. A number of ducts greatly in excess of the estimated requirements had best be laid when the installation is first made, the extra ducts being for the purpose of providing ventilation and space for additional cables.

Manholes are placed in every length of conduit of not more than 500 ft., the allowable distance between manholes being governed by the size of cables to be installed. Cables two inches or more in diameter are extremely heavy and the distance between manholes had best be reduced to not more than 300 ft. when such large cables are to be installed. The street layout governs the locations of manholes to a very large extent, one manhole being usually placed at each street corner. The object in placing them at the corners is to provide points for connection to all streets crossed for any service that may be required in the future.

It is important to make manholes of ample size, where possible, though numerous gas and water pipes often limit the allowable size in large cities. At street corners the size should not be less than six by six feet, though where the manhole is to be used for pulling the cable through the duct only, as when installed in the center of a block, a four by six foot manhole is sufficient. The length and heighth of wall must allow of splices on a number of cables equal to the number of ducts, otherwise when additions are made to the system space will not be found for connecting the cables.

A floor of six inches of concrete, with four or five layers of tarred paper and a top dressing of cement, walls eight inches thick, of brick laid in cement, and brick arch top with I-beams form a durable construction in most locations. Cast-iron covers, especially designed for this service, can be obtained with opening and lid sufficiently strong to resist ordinary street traffic. The manhole is drained by a trapped outlet to the sewer and numerous vents in the lid permit the escape of sewer gas. Sewer gas will accumulate in manholes, and even though openings be provided for ventilation no one should be permitted to place a light near them when first opened. The gas should be allowed sufficient time to escape.

Wooden beams should be built into the walls of the manholes for the purpose of securing cable hangers thereto. These are often omitted and cable hangers can only be secured to the walls with great difficulty.

Paper insulated lead covered cable is almost universal for underground work. The thickness of this insulation must be sufficient to resist bending when installing the cable, this fact being often overlooked when specifying the insulation thickness, the thickness being required to resist the voltage only without regard to mechanical stresses produced by short bends. It is imperative to prevent workmen from making short bends in the cable, for which reason it is best to fill in the corners of the manholes and to round the approaches to the ducts.

Three-conductor cables are made with paper insulation around each conductor and a belt around the set of three, all covered with a lead sheath. The paper must be sufficiently flexible to withstand bending when the cable is installed. It must be of a uniform thickness throughout and the lead sheath must be of one uniform thickness. There must be no holes in the lead sheath.

If a very high resistance of insulation is specified, the insulation must be thoroughly dried before testing; this drying out of the insulation makes it brittle, so that it is liable to crack when the cable is bent. A moderately high breakdown potential test applied momentarily is all that is necessary. This test should be made after the cable is installed, as it shows faults at bends and joints.

Rubber compound gives better results than paper insulation, when the cable is submerged under water, owing to the probability of the water finding its way through the lead covering. For ordinary street work, however, when water is present only occasionally, paper is all that can be desired.

Small holes in the lead covering must be avoided, as a breakdown will develop at such points. These can be discovered by careful inspection, but the cost of inspection by the operating company does not warrant this, the manufacturer being depended upon to supply a perfectly tight lead sheath.

An alloy of lead and tin makes a hard metal, a small percentage of tin producing an alloy much more capable of resisting the abrasion when pulling the cable through the duct than does pure lead. This addition of tin increases the cost, but it is better to sacrifice a slight amount of thickness than to omit the tin entirely.

Large cables are stranded. These cables can be made up from 7, 19, 37, 61, 91, 127 and 169 small wires, and these numbers only can be supplied, otherwise the outside conductors will not lie close together. There is one central wire; the layer around this wire has six wires, the next layer has 12 wires, the next 18, the next 24, each layer adding twice the diameter of one to the whole and increasing the circumference by six times its diameter. This is due to the fact that the circumference of a circle is 3.14 times its diameter, and the decimal 0.14 is taken up by twisting the wires. Rope-laid cable can be made from any multiple of seven wires, and this is done where extreme flexibility is required. The outside circumference of rope-laid cable is not as smooth as cable made up as described above with the same size wires. An increased amount of insulation is therefore necessary to fill the spaces between the strands, the full advantage of the total quantity of insulation not being obtained and the external diameter of the cable is larger.

When transmitting alternating current with lead-covered cables, the two wires for single phase or the three wires for three-phase systems must be under one lead sheath; there should be no magnetic field cutting the metallic sheath. While it is well known that individual wires in iron pipe cause an excessive drop in voltage, it is not so universally known that individual wires in separate lead sheaths will cause heating of the cable. Current in the conductor induces a reverse current in the lead sheath, the amount of current in the sheath being limited by the resistance of the lead and by the resistance of the contacts between the sheaths at the ends of the two cables. The voltage may be only a few volts, but, with secure connections at each end of a pair of cables, such as is afforded by iron cable hangers, the resistance of the lead circuit is so low that a current approximating in value the current in the copper will flow in the lead. The current induced in the lead would equal the current in the copper if the lead circuit has no resistance and the insulation between the lead and copper is very thin. Usually the cables are run in separate ducts, and unless the cables are hung on iron hangers, with a metallic connection between them, the connections at the ends of the pairs of cables have a resistance above 10 ohms, so that the current in the sheath is so small that it may be neglected. However, cables are frequently hung with their lead sheaths in contact with a metallic hanger common to all, and frequently cables are bonded to trolley tracks or to a copper conductor, in which cases the induced current will greatly increase the heating of the cables, a much less rise of temperature being obtained with smaller cables of the multiple conductor type.

In order to limit this induced current to a small amount, two single conductors should not be drawn into one duct and allowed to have their sheaths in contact. Some form of insulation should be provided between the lead sheaths and at metallic cable hangers. Where cables are connected by bonds to trolley tracks this connection should be made only at one end of the cables.

Besides the current induced in the sheaths by the current in the conductors a charging current flows between the lead sheaths, this charging current depending on the voltage of the circuit, on the thickness of the insulation and on the material of which the insulation is composed. If two lead-covered cables be connected to the two terminals of a source of electromotive force (alternating or direct), the cable connected to the positive terminal has a negative charge induced on the sheath and the cable connected to the negative terminal has a positive charge induced on its sheath. Where the voltage is maintained at one constant value, as with a direct electromotive force, a small current flows between the sheaths, producing a charge on each. Where the voltage is continually changing, as with an alternating electromotive force, a current flows between the sheaths, producing alternately positive and negative charges on each, the amount of this current depending on the electrostatic capacity of the cables, on the voltage and on the frequency. When the supply of electromotive force to the cables is suddenly disconnected, as when a switch is opened, the electrostatic voltage sometimes rises to an immense value, sufficient to jump an air gap of 10 in. or more, and sufficient to puncture the best insulation that may be separating the lead sheaths. The amount of energy is small where the electrostatic capacity of the cable system is moderate, so the first spark carries the entire discharge, no arc being formed. The static effect is also observed on multiple conductor cables when the voltages of the different conductors do not neutralize with respect to the ground potential. The potential of the lead sheath should be neutral with respect to the potential of all the conductors covered by the sheath. The total current flowing through the conductors under any one sheath should be zero when measured with respect to the direction of flow of current, in order to prevent induced current in the lead sheath. Underground cable systems should be maintained with a balance of voltage and the load on the different phases should be balanced.

Lead-covered cables are affected by current from adjacent street car tracks, the lead following the direction of current. Trolley wires are connected to the positive switchboard bus at the railway power station. Current flows along the trolley wire to the car, to the tracks and back to the railway power station negative bus. In flowing from the car to the power station, the current divides over many paths and in proportion to the relative conductivities of the different paths. The lead sheath of an underground cable forms a part of one of the numerous paths to the railway station, with the result that some current flows along this sheath and leaves it at some point on its passage. Where the current leaves the lead sheath, the lead follows the current, causing pitting and disintegration of the sheath. Complete destruction of the lead covering the cable may be caused within a few weeks under extreme conditions.

One method of preventing electrolysis is to prevent the railway current from flowing to the cable by insulating the lead sheath from the ground as much as possible. This is not possible, however, during damp weather except by completely covering the lead sheath with a waterproof insulation. Another method of preventing electrolysis is to provide a low resistance path from the cable to the trolley track at points where the current flows from the cable sheath to the tracks, that is, by bonding the cable sheath to the trolley tracks at these points. Indiscriminate bonding of sheaths to tracks is not advisable, since low-resistance circuits are thus provided from the track to the sheaths as well as from the sheath to the track. As soon as the first cable is installed in the conduit system the potential from cable to track should be tested with a low-reading voltmeter. Wherever the track is positive to the sheath, the sheath should be insulated from the ground by providing thorough drainage of manholes and conduit and by winding tape around the lead sheath at cable hangers. Wherever the track is negative to the sheath, the cable should be joined to the track by heavy copper wire. This bond must be as carefully made as any bonds are made between tracks on a railway return circuit, otherwise the connections will rust and the bond will become inoperative.

Some companies install a heavy copper conductor in one of the ducts of a conduit system and bond all the lead coverings to this conductor at every manhole, bonding this conductor to the trolley tracks at points where the tracks are negative to the conductor. A better plan is to treat this conductor the same as the railway tracks, bonding the cable sheaths to it only where the test by voltmeter shows the current to be flowing from the cable sheaths to the conductor. Otherwise the bare copper conductor tends to add to the current in the lead sheaths by its additional surface collecting current from the near-by tracks through the ground.

Joints and splices of lead-covered cables should only be made by experienced men; others should not attempt this work without proper instructions. Lead sleeves of a larger diameter than the cable are slipped over the end of one section of the cable to be joined; the conductors are slipped into copper connectors, the joints soldered, then wrapped with gum tape and cemented with a rubber solution. The ends of the lead sleeves are soldered to the cable sheath with a wiped joint, and the sleeves filled with an insulating moisture-proof compound through holes in the sleeves, which are later closed by soldered caps. All moisture and acid must be removed from the joint before sealing. The flux used for soldering and the moisture are driven off by slightly heating the joint; too much heat will injure the cable insulation. Similarly the sealing compound must be heated and must not be too hot when poured into the sleeve around the joint. The degree to which heat should be applied can only be determined by experience, the novice either scorching the insulation or not applying sufficient heat to do the work. All ends of cables should be sealed with lead plugs until the time of making the joint and joints should only be made in dry weather.

Junctions of branch cables are made in a manner similar to that described above for connecting joints. In every case of making joints and junctions the material, connectors, sleeves and compounds made for the purpose should be used, as hasty work with materials unsuited to the purpose will almost always prove a source of later trouble.

One, Two and Three Phase Systems

The three-phase system of power transmission is considered as more economical than single-phase or two-phase system and this is the main reason for its adoption in most cases. While it is true that a three-phase transmission line has a less loss per pound of copper than a single or two-phase transmission line, when the voltage between wires is taken as a basis for comparison, the loss for any given size of wire is the same for the three systems when the voltage is measured between wires and ground. Therefore, three-phase transmission lines, as now installed with ground connections, give no economy in weight of copper over the other systems for transmitting power.

Three-phase transmissions have an advantage over those of two-phase in that three wires of one size are used for transmitting the power, while the two-phase system requires four wires or three wires, one wire of the three being 40 per cent. larger than the other two. Also the voltage between outside wires of the two-phase system is slightly higher than the maximum voltage between wires on the three-phase system for equal weights of copper and equal losses. However, when the limiting voltage is the safe voltage which the line insulators will withstand, and where there is a ground connection, the single-phase, two-phase and three-phase systems require equal weights of copper.

Although the saving in copper obtained is only applicable to ungrounded systems, where the limiting voltage is the voltage between wires, the polyphase systems are more desirable than the single-phase system when the cost of the generators is considered. Only a part of the generator armature can be supplied with windings for single-phase, thus requiring a larger generator per kilowatt output than is required for two or three-phase machines, since polyphase generators have windings around the complete armature circumference. In consequence of the larger machines required for operating single phase, the cost is slightly in excess of that for polyphase.

In small lighting plants, with nearly all of the feeders supplying single-phase light and power, generators of the two-phase type permit of balancing the single-phase feeders on the two phases of the systems by means of double-throw switches, which advantage is often found so desirable that the two-phase system is adopted for small plants.

In single-phase railway traction service, a two-phase generating station permits of feeding the length of track on one side of the station by one phase and the length of track on the other side of the station by the other phase, conditions permitting of a balanced system with a majority of installations. Another advantage of the two-phase system over the three-phase consists of the number of transformers required for changing the voltage, since two suffice instead of the three required for the three-phase system.

The three-phase system is usually adopted for moderately large and for large central stations owing to three wires of one size serving for conducting the current and to its economy of copper when the voltage is measured between wires. With the three-phase transformers now on the market the objection to the use of three transformers for power is overcome. However, single-phase transformers allow of using the transformers in stock for light or power, so that the two-phase system has some advantages for small light and power stations.

Each particular station has special conditions governing the desirability of the system to be installed and which must be treated separately in each case. Unless some special condition, such as the necessity of balancing a small number of single-phase feeders, or where the desirability of two transformers in place of three is considered of importance, the three-phase system should be adopted. This is in line with the general tendency of the present time to accept it as a standard.

Delta and Star Connections

The relative merits of delta and star connections depend on whether the limiting voltage is reached with the transformers or with the line insulators.

Where step-up transformers are required, that is, for voltages above 11,000 volts, where it is cheaper to install low voltage generators and raise the voltage by single-phase transformers, the maximum voltage of line is obtained by connecting the transformers in star.

With three 30,000-volt transformers connected in star, the voltage between each wire and the ground is 30,000 volts, and the transmission line will be equal in copper economy to a 30,000-60,000 volt three-wire single-phase system with grounded neutral. With three 30,000-volt transformers connected in delta, the voltage between each wire and the ground will be 17,300 volts, and the system will require the same amount of copper as three 17,300-volt transformers connected in star. Obviously, therefore, the cost of transformers is less with the star connection, since the service is supplied by 17,300-volt transformers instead of by 30,000-volt transformers.

Frequently the generator windings are wound with the three phases independent and insulated to withstand delta or star connections, so that these machines may be connected in star with the advantage of obtaining the higher economy of star connection.

The desirable characteristic of the three-phase system in economizing copper is then only apparent in minimizing the voltage between wires, and this desirable characteristic is only apparent when the line is not connected to ground.

This characteristic has its value, however, in that the insulators of a delta-connected three-phase system need only withstand 86 per cent. of the voltage of a grounded star-connected system with the same voltage between wires. Cheaper insulators may therefore be installed on a delta-connected than on a star-connected system.

For a 30,000-volt system with grounded neutral, the voltage across insulators from wire to pin is 17,300 volts, while without the grounded neutral the voltage at this point, under normal working conditions, is only 15,000 volts. Also for plants of moderate size, where the wires are run through trees and under other adverse conditions, trouble is continually experienced from accidental grounds to one or more wires. With these plants the important desideratum is to keep operating, and a system without grounded neutral allows of operation even though one wire be accidentally grounded. The delta-connected three-phase system then has advantages not possessed by the star-connected system.

These considerations lead up to the question of the desirability of grounding the neutral, a subject discussed at length during the October meeting in New York of the American Institute of Electrical Engineers.

Grounded Neutral

The grounded neutral was first introduced by companies transmitting power at high voltages with the transformers connected in star; the star connection of transformers permitting of using transformers of a lower voltage and consequently lower cost than the delta connection with the same voltage between wires.

With any unbalancing of the current on the three phases of lines connected in star, the voltage is raised across the terminals of one or two transformers and lowered across the terminals of the remaining transformers; this increased voltage at the transformer primary terminals producing an increase of magnetism in the transformer, thus unduly heating the core.

When the neutral is grounded, a current flows through the ground between the transformers at the two ends of the line, causing them to operate in a manner similar to three single-phase transformers each carrying the load on the phase to which it is connected, the voltages across the three phases differing only from their no-load values by the amount of transformer regulation.

As an analogy, two transformers may be considered as connected in series on a 2000-volt line, each taking 1000 volts at no-load. If one transformer be loaded, the current to supply it must flow through the other transformer. A much higher voltage than normal is required to force this current through the primary winding of the second transformer and the voltage at its terminals will be higher than normal, while the voltage at the loaded transformer will be greatly less than normal. Similarly, the secondary voltages of these two transformers will be unsuited to the load, the secondary voltage supplying the load being too low for satisfactory operation and the voltage on the lightly loaded side of the system being so high as to endanger any lights or power supplied by it. Now if a third wire be run from the supply to the receiving end of the line, or if the two ends of the line be securely grounded at the neutral point, 1000 volts will be across each transformer, thus producing normal conditions. Similarly, the voltages at the three transformers of a star-connected three-phase system are balanced by a neutral wire or ground connection.

When two or more banks of transformers or generators are operating in parallel in a station, a neutral connection preserves a balance on the phases at times of switching. When feeders are disconnected one phase may be disconnected before the others, thus producing an abnormal voltage across the other phases at the instant of opening a breaker unless there is a neutral connection to preserve a balance.

Again considering our analogy of two transformers in series, if one be disconnected from the line the voltage is 2000 volts between the blades of the switch at the point of disconnection, while if there is a neutral connection the voltage at the switch contacts is only 1000 volts.

Resistance in Grounded Neutral

With the grounded neutral, when any one wire is connected to ground a severe short circuit is obtained, the severity depending on the resistance of the ground connection and the ground resistance to the point of ground at the power station.

With aerial transmission lines, the resistance of the ground return is considerable, and short circuits due to the grounding of any one wire are not of low resistance. These lines rarely require the addition of resistance at the station.

With underground systems and lead-covered wire, the resistance of the ground return is very low. Therefore, any connection of one wire to ground causes a large rush of current. In order to limit current due to short circuits to a moderately heavy overload, resistances are inserted between the ground at the central station and the neutral connection of the generators.

Such a resistance must be low in order to preserve the value of the ground connection as a balancer. Otherwise the drop in voltage due to unbalanced current flowing through the resistance neutralizes the value of the ground connection and not much better results are obtained than with ungrounded neutral.

Another aspect, the one given consideration at the October meeting of the American Institute of Electrical Engineers, is the question of opening the circuit-breaker automatically when a ground occurs. The resistance should always be of a low enough value to cause the breakers to operate, since, if it is higher than this value, a ground may be maintained at some point on the line with the result of injury to adjacent cables or other property.

As previously mentioned in the May issue of this paper (page 226), resistances must be provided in the station to protect the generators when switching on and off the bus bars, that is, each generator should have its own resistance. This resistance should be of as low an ohmic value as the kilowatt capacity at any short circuit will permit, and in order to prevent maintaining the short circuit should be low enough to allow a flow of current that will operate any feeder circuit-breaker.

Circuit-breakers are made to break a given capacity in kilovolt amperes, therefore the resistance should not be so low that the feeder breaker cannot handle the short circuit. The circuit-breakers then determine upper and lower limits for this resistance from the standpoint of circuit-breaker operation, while the advantages to be obtained from grounding the neutral at all limit the highest value of this resistance.

The maximum possible amount of current unbalancing should be estimated for the system and the effect of the resistance drop in voltage with this current should be calculated. The maximum resistance is then that which gives the maximum allowable voltage unbalancing.

Cast-iron resistance appears desirable for use owing to its property of increasing resistance with increasing temperature. Its resistance is low under normal operating conditions, with the flow of only unbalancing current, it thus being effective in maintaining a balance. Short circuits cause such a rush of current that the temperature of the resistance is raised almost immediately, thus increasing the ohmic value, reducing the current and securing safe operation of the circuit breakers, instead of taxing them with heavy overloads.

The cast-iron grid resistance has a very low inductance, due to its construction, which also adapts it to this work. Resistances of this type are designed for low inductance in order to minimize sparking at switching apparatus, controllers and rheostats. It is a mistake to suppose that they have a high inductance simply because they are made of iron; the shape of the grids produces a flow of current with a minimum field in spite of the fact that they are made of iron.

Conditions Producing a Higher Voltage than Normal at the Receiving End of a Line

CHARLES JENKINS SPENCER

THE conditions producing a higher voltage than normal at the receiving end of a line are best described by describing these conditions first for a direct-current three-wire line, then for a single-phase three-wire line and lastly for a three-phase with grounded neutral. In all of these transmissions, a low resistance neutral connection between the source of supply and apparatus operated is essential for satisfactory operation, and any resistance added to the neutral wire partly defeats its function of balancing the load.

The wiring for lighting a building must be of a size to prevent an excessive drop in potential from the main switch to the last lamp on each circuit, as the light will otherwise vary with variation of load to too great an extent for satisfactory service. This drop in potential is specified by the engineer in charge of the work, the limit for uniform lighting being generally three per cent. of the service voltage. Thus, on a 110-volt service the voltage at any lamp must not be less than 106.7 volts, and with a 220-volt service the voltage at the last lamp must not be less than 213.4 volts. When testing the drop in potential on a three-wire 110-220-volt feeder, the voltage at the farthest lamp may be found to be higher than the voltage at the main switch on the same side of the feeder. This condition shows the load to be so greatly unbalanced that a larger neutral wire must be installed for satisfactory service, as otherwise the voltage on the heavily loaded side cannot be maintained at even approximately its normal value.

Suppose three arc lamps to be connected to a 110-220-volt service, as shown in Fig. 1. Each lamp takes six amperes at 110 volts, the length of circuit is 500 ft., the size of each outside wire is No. 10 B. & S. and the neutral wire is No. 14 B.&S. The resistance of 500 ft. of No. 10 B. & S. wire is 0.5 ohm and the resistance of 500 ft. of No. 14 B. & S. wire is 1.25 ohm.

With the lamps connected as shown in Fig. 1 the current in one outside wire is 12 amperes, in the other outside wire it is six amperes, and it is six amperes in the neutral wire. The positive side of the supply is connected to that side of the three-wire system supplying the two arc lamps, that is, the positive wire carries 12 amperes and the drop in potential in this wire, from the main switch to the two arc lamps, is

12 amperes $\times$ 0.5 ohms = 6.0 volts.

Plot this drop in voltage as shown by Fig. 2.

The current along the neutral wire is from the lamps to the source of supply, and the voltage at the lamps must be positive to that at the neutral blade of the service switch. This drop in voltage is

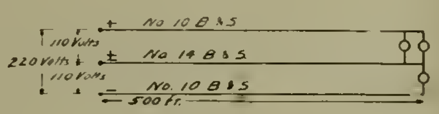


FIG. I.

6 amperes × 1.25 ohms = 7.5 volts.

Plot this drop in voltage as shown in Fig. 2.

The current along the negative wire is from the lamp to the supply and the voltage at the lamp must be positive to that at the service switch. This drop in voltage is

6 amperes × 0.5 ohms =3.0 volts.

Plot this drop in voltage as shown in Fig. 2.

Fig. 2 is drawn to scale, permitting the voltage at the lamps to be scaled approximately.

The voltage at the lamps can also be calculated by adding and subtracting the drops in voltage on the different wires. Thus the voltage at the two lamps is

110 volts—6 volts—7.5 volts=96.5 volts.

The voltage across the terminals of the two lamps will then read 96.5 volts.

The voltage at the single lamp is

110 volts—3 volts+7.5 volts= 114.5 volts.

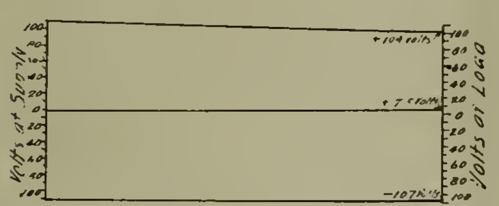


FIG. 2.

The voltage across the terminals of the single lamp reads 114.5 volts, that is, higher than the voltage at the main switch on the same side of the service.

In a three-wire system, good practice requires the three wires of any one feeder or circuit to be of one size in order that the neutral wire have equal carrying capacity to that of each outside wire. Conforming with good practice by installing three wires of one size for this circuit, three wires each No. 10 B. & S. are used. The drop in voltage is then as shown by Fig. 3. Here the drop in voltage along the positive wire is

12 amperes × 0.5 ohms = 6.0 volts, along the negative wire it is

6 amperes × 0.5 ohms = 3.0 volts, and along the neutral it is

6 amperes × 0.5 ohms = 3.0 volts.

The voltage at the two lamps is

110 volts — 6 volts — 3 volts = 101 volts,

and the voltage at the single lamps is

110 volts — 3 volts + 3 volts = 110 volts.

In this case the voltage at the single lamp is the same as at the main switch.

The voltage with No. 10 B. & S. neutral wire does not come within the three per cent. drop in potential required, and larger wire should be used.

Applying the same reasoning to an alternating-current line with transformers, similar results are secured, but with this difference: The transformer primary is not disconnected from the line when the load is removed and an excessively high voltage will injure the transformer.

Take, for instance, a transmission of 1000-2000 volts three wire with neutral wire of small cross section as follows:

Power transmitted = 100 kw.

Transformers receiving power = Two 50 kw. each.

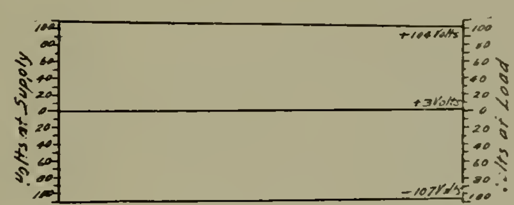


FIG. 3.

The line = Three wires, the outside wires being twice the size of the neutral and having five per cent. drop in voltage each at full load.

With these conditions, consider that one receiving transformer is carrying full load and that the other transformer is under no load. That side of the line connected to the transformer carrying full load will have a five per cent. drop in voltage and the current returns along the neutral wire. On the assumption that the potential drop per ampere in the neutral is twice the potential drop in one outside wire, there will be a 10 per cent. drop in voltage in the neutral, giving a total of 15 per cent. drop in voltage at the loaded transformer. The drop in voltage in the neutral wire so unbalances this system that a voltage 10 per cent. higher than normal is impressed on the unloaded transformer (see Fig. 4).

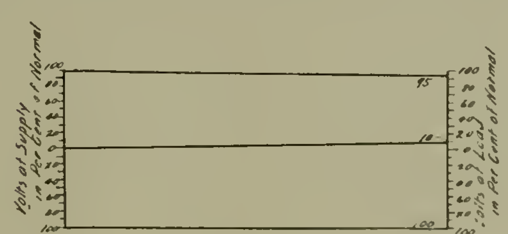


FIG. 4.

Transformers will stand a voltage 10 per cent. above normal but will rapidly heat with voltages in excess of 25 per cent. above normal owing to the increase of core magnetization. Suppose, now, the neutral points of the supply and receiving transformers be connected to ground and that the neutral wire be omitted, the ground connection being relied upon to carry the unbalanced current. The resistance of ground connections may become almost any amount with changes in the soil. A coincidence of conditions, when the ground return resistance is high and the load on the two transformers is unbalanced, is not out of the ordinary. A poor ground return resistance might very well be 10 times the resistance of one of the wires with the result shown in Fig. 5. Here it will be seen that the voltage across the terminals of the unloaded transformer is raised to 50 per cent. above normal, or sufficient to cause excessive heating of this transformer core, burning out the insulation and causing its destruction.

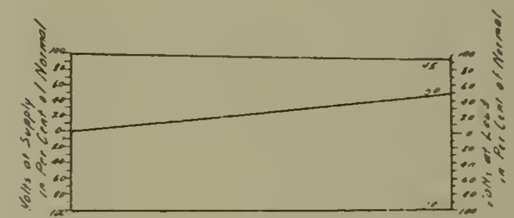


FIG. 5.

Three-wire single-phase transmission systems are unusual. The above example is given only for the purpose of leading up to those large three-phase systems with grounded neutral which are now so common, and other systems with resistances connected in the grounded neutral.

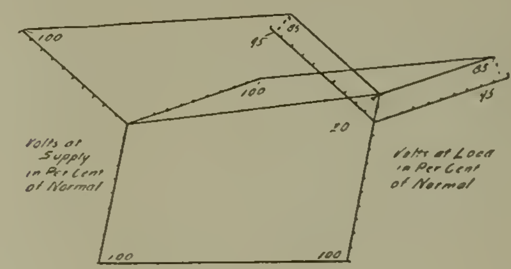


FIG. 6.

Whether the transmission be underground or overhead the same conditions hold no matter whether the load be unbalanced or balanced perfectly, as in feeding rotary converters. When the load consists of transformers supplying a rotary converter, one transformer secondary may become disconnected accidentally, or at times one switch in the secondary of a bank of three transformers may be left open unintentionally or at times of connection to the rotary. The large capacity required of these switches necessitates single-pole switches which cannot be thrown in or out exactly simultaneously.

With a three-phase star-connected system and one leg of the secondary at the receiving end open, the electric power supplied by two of the primary wires is returned by the ground connection. The current along the two wires composing the two legs of a three-phase current is added geometrically to compute the ground current.

Taking the line drop per leg as 10 per cent. or five per cent. per wire, and the drop in potential along the neutral with current equal to normal load as four times that of one wire—or, neglecting effects of inductance and capacity, say the ground resistance is four times the resistance of one wire—the potentials at the receiving end of the line are as plotted in Fig. 6. The current along the neutral is equal to the current in one leg, giving as the neutral potential drop

5 per cent. $\times$ 4 = 20 per cent.

The voltage at the receiving transformer with open secondary is 20 per cent. above normal. This is near the allowable limit for increase of voltage above normal for the average transformer, a higher voltage will cause excessive core loss with accompanying rise of temperature.

When designing resistances for connection in the grounded neutral of a transmission line, an ohmic value should, in general, be selected which, when added to that of the ground return, will not be above four times that of one wire. Resistances of a higher value neutralize the benefits to be derived from the grounded neutral in properly balancing the load.

The Starting of Rotary Converters

GEORGE I. RHODES

Engineer, Interborough Rapid Transit Company

THE object of this paper is to describe several methods of starting rotary converters and to state the relative advantages of each.

These methods are considered with respect to certainty of operation, ease and rapidity of synchronizing, disturbance to system and apparatus connected thereto, and simplicity of wiring and operation.

The methods for starting from the alternating-current side are as follows:

As an induction motor.

By a small induction motor attached to the shaft.

In case of total shut-down of a system, by bringing several rotary converters up to speed and voltage simultaneously with one generator.

The methods for starting from the direct-current side are:

From the bus bars.

From a small motor generator set.

Any polyphase synchronous machine may be started from rest by connecting it to the line either directly, to transformers with low voltage taps, or through resistances or reactances.

In machines which have no dampers on the pole pieces and have field windings open-circuited, rotation results principally from hysteresis effects; that is, these machines start as hysteresis motors. In machines of commercial design, the torque produced by this effect is sufficient to start them even at half voltage or less. The current which flows is of very low power factor, the greater part of it producing the rotating field.

If the field coils are short-circuited, or if the machines have heavy dampers to prevent hunting, the starting current will be much larger than for machines with open circuited field coils and no dampers. The torque will also be larger; the dampers and the closed coils on the field circuits producing an induction motor action. It has been found by the writer that the starting torque with certain small machines may be very considerably increased by connecting a resistance across the terminals of the field coils, the resistance being of a value to cause maximum torque to be produced at standstill.

In any case, the starting of a rotary converter as an induction motor or as a hysteresis motor although certain in operation can be accomplished only by drawing an excessive current from the line. This large current may produce serious effects. Being at a very low power factor, probably never in excess of 20 per cent., it will produce a large voltage drop both in the line and in the generator, and, if the rotary converters are large as compared with the generating capacity the fluctuations in voltage may be sufficient to cause trouble for other rotary converters that may be running or to make it somewhat difficult to synchronize in other substations connected to these generators. There is, however, another possible danger from this large current of low-power factor in systems having large electrostatic capacity, such as underground distributing systems. The natural frequency of some of these systems is so low that the sudden draft of a large amount of inductive current is liable to produce surges with resulting high voltages dangerous to the cable insulation.

In rotary converters designed to be started directly from the alternating current side provision must be made to split the field coils into several sections, otherwise, the potential produced in the field circuits by the alternating flux passing through the iron cores will be so large as to become dangerous to insulation. In small machines having 110-volt excitation which the writer has tested, potentials are induced in the field coils aggregating from 1500 to 2500 volts. In large machines for 600 volt excitation, such as are used in railway work, the induced voltage will be very considerably in excess of this. The splitting of the field to limit the potential to that of a portion of the winding requires a multipole switch which on account of its small size and apparent unimportance may give a chance for trouble.

Provision for starting rotary converters by the above method requires extra switches which should be of a capacity comparable to those used in ordinary operation. In rotary converters of large size, it is necessary to have single pole switches thrown by hand or large motor-operated switches. In low voltage machines with six phases such as are used in lighting work, these switches may be of very large size and on account of their number introduce operating difficulties in starting. With machines of small size the switching arrangements may easily be made quite simple.

The great advantage of the method of starting a rotary converter as an induction motor is the elimination of synchronizing. When the machine has attained its speed it is merely necessary to close the field circuit and the rotary converter will be pulled into step. It is by no means certain, however, that the polarity will be right. With machines running in this way, the polarity is determined by the phase of the current at the instant the field circuit is closed with equal chances that it may be right or wrong. In case the polarity is wrong, it is necessary to open the field circuit and try again. In one system using this method of starting the polarity is found to be correct somewhat oftener than half the time, though there have been cases where at times of emergency the voltage built up in the wrong direction several times in succession. The uncertainty of obtaining correct polarity may cause very considerable delays in getting a rotary converter on the line.

It is not necessary that the field of the rotary converter be closed upon its own armature terminals, it may first be closed on the bus bars of the direct-current switchboard, thus predetermining the polarity of the machine. In case of a total shut-down, however, the first machine may come up to voltage in the wrong direction unless there are storage batteries to keep the bus bars alive.

To sum up, then, the starting of rotary converters directly from the alternating-current side may be accomplished with certainty but only with a very considerable and possibly dangerous disturbance to the generating system. The necessity for the somewhat delicate operation of synchronizing is removed, but on the other hand there is an uncertainty of polarity unless means be provided for continually maintaining a voltage at the direct-current bus bars. Although this method may be suitable for substations having a few small rotary converters, it hardly seems suitable for regular use in substations of very large capacity such as are a part of lighting and railway systems of large cities.

Instead of starting a rotary converter as an induction motor, it may be started by a small induction motor mounted on the same shaft. This method removes the most serious trouble incident to starting from the alternating-current side. There is no disturbance to the system when the small induction motor is connected to the line, there are no dangerous potentials produced in the field coils of the rotary converter, and the polarity is fixed to the same extent that it is in a direct-current system. The necessary wiring and switches are of small size and may easily be located in the most convenient position. On the other hand there is the necessity of synchronizing.

An induction motor attached to the shaft of a rotary converter has fewer poles so that its synchronous speed is above that of the rotary converter. It is designed for a large slip so that it will run the unloaded machine at about synchronous speed. A large slip requires a secondary winding of high resistance so that the starting torque of such an induction motor will be high. There is no convenient method of varying the speed of the motor to adjust for synchronism, except by changing the torque necessary to drive the rotary converter. This is accomplished by varying the field strength and consequently the iron losses. The speed may be adjusted to synchronous speed by this method, but it is not possible to adjust the voltage at the same time and it may be necessary to synchronize with the voltage of the incoming machine considerably different from that of the bus bars.

The starting torque of an induction motor is directly proportional to the square of the voltage so that, unless the motor is of liberal design, it may not start under low voltage conditions.

A certain substation recently under the writer's observation in which there are a number of 800-kw., 25-cycle, 8-pole, 500-volt rotary converters employs the method of starting by means of an induction motor. Usually there is no serious trouble in synchronizing, but there have been times when the system was a little below normal voltage and the rotary converter would refuse to start, making it necessary to help the machine along. As soon as the static friction was broken the machine started all right, but it was impossible to obtain synchronous speed without having the voltage of the incoming machine very much below that of the bus bars. It has been found that considerable skill is required to synchronize these machines rapidly.

The method of starting by means of a small induction motor has a great many advantages over the first method. No disturbances are created on the system and the method is simple. However, considerable skill is required for synchronizing and a starting motor is required for each machine, this motor adding materially to the cost in spite of its small size.

After a complete shut-down of a large system, certain circumstances may make desirable the starting of rotary converters in several substations simultaneously by connecting them to a dead generator and gradually bringing the generator and rotary converters up to speed and voltage together. This scheme has been tried successfully by the Chicago Edison Company as described by Mr. John E. Hill in the February number of The Electrical Age. The same scheme has been tried on other systems with poorer results than those secured by the above-named company.

In starting up a system in this manner, the rotary converters may be either self-excited or excited from a storage battery. Where no storage battery is available, the polarity of the rotary converters will be indeterminate as it is when starting directly from the alternating current bus bars. The uncertainty of the polarity makes it undesirable to start more than one rotary at a time in a substation or to connect several substations in parallel until after the polarity has been determined. On account of the large torque necessary to start a rotary converter from rest the number which may be started in this manner is limited.

In a number of tests made by the Interborough Rapid Transit Company some years ago it found that not more than three rotary converters could be started with certainty from a single generator. These rotary converters were of 1500-kw. capacity each, and the generators of 6000-kw. rating with a continuous overload capacity of about 9000 kw. When more than three machines were connected for starting together, one or more machines would frequently refuse to start, merely vibrating and humming very violently.

The starting of self-excited rotary converters by this method has the objection of very large inductive currents. In starting a single rotary converter as an induction motor from a fully loaded system, the large inductive current may cause trouble on an underground system, but in starting several machines in this way from an unloaded system the possibility of surges is much greater.

With separate excitation such as may be obtained in a station equipped with a storage battery, even if the battery is pretty much exhausted the polarity is determined with certainty and the rotary converters will start with much greater certainty, they being in complete synchronism at all times. This latter variation of the method seems to be the one found successful by the Chicago Edison Company. These two methods, that is, starting with or without storage batteries from a generator in which the speed and voltage are increased simultaneously have one great objection, they are methods for use only after a complete shut-down. They require in the trying period immediately following the shut-down that the operators perform operations different from those ordinarily practised. The possibilities of mistake are much greater than with a method in which the operators perform exactly the same operations that they perform several times each day under ordinary operation.

Rotary converters may be started as direct-current motors, either from the direct-current bus bars, or from a small motor-generator set consisting of a direct-current generator driven by an induction motor, and supplied especially for this purpose. In substations having no reserve capacity in storage batteries, a starting set is necessary after a shut-down. In starting it is required to have a rheostat with multipoint short circuiting switch and the excitation must be taken outside of the resistance at start and then transferred to the rotary converter terminals by means of a double-point switch with preventive resistances, after the rheostat has been short-circuited. This is

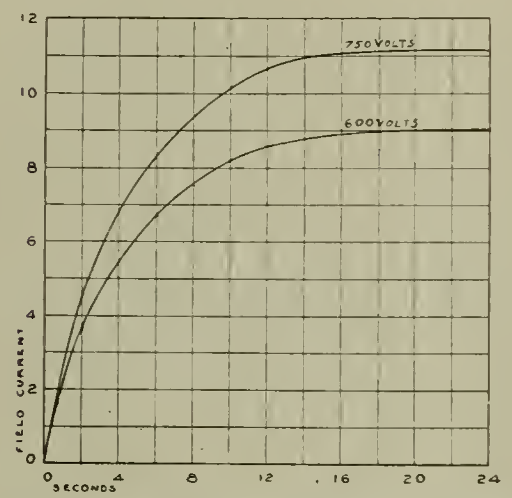


FIG. 1.—TIME REQUIRED FOR RISE OF FIELD CURRENT OF A 1500 KW. 600 VOLT ROTARY CONVERTER.

necessary to give sufficient excitation at start and later to remove the starting rheostat from the circuit for use on other machines.

Starting from the direct-current side may be accomplished in the quickest time with no disturbance to the system. With machines having open switches in the secondary circuits, the first rush of current necessary to start need be no greater than 15 per cent. of full load current of the rotary converter and after the machine turns over satisfactory results may be obtained with less than 10 per cent. of the rated current. When the second-

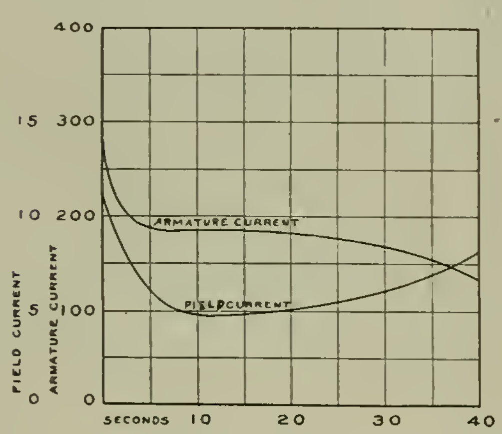


FIG. 2.—STARTING CURRENTS OF A 1500 KW. 600 VOLT ROTARY CONVERTER, SUPPLIED FROM A 50 KW. 750 VOLT SHUNT WOUND STARTING SET THROUGH 1.3 OHMS RESISTANCE.

aries of the transformers are permanently connected to the slip rings of the rotary converter, approximately 30 per cent. of full load current may be required at first on account of the shunting action of the transformer coils. After the rotary converter has begun to turn over the secondary switches may be closed without any material increase of current. Although the use of secondary switches slightly increases the number of operations required, it has the advantage of giving the operator something to do after first closing the switch for starting before he begins to cut out the starting resistance. This advantage is rather noticeable when starting sets of small capacity are used, for an appreciable time is taken for the voltage to pick up after the first heavy rush of current.

When a starting set is used, it is usually designed for a no-load voltage considerably in excess of the rotary converter voltage. Either a shunt or a very much undercompounded generator must be used for starting, to prevent the motor generator set from running away should the alternating-current motor be disconnected from the line after the voltage at the rotary converter has been built up, and before the connection between the rotary converter and the starting generator is opened. The size of the starting generator need not exceed six per cent. of the rating of the rotary converter to give perfectly satisfactory results, even though several machines be started one immediately following the other. A starting set of half the above size will start two or three rotary converters without trouble, but this duty will so increase its temperature that later machines will start rather slowly.

When starting from the direct-current bus bars, more resistance is desirable in the starting rheostat to prevent excessive current than when a starting set is used. There is another need for this extra resistance which will be described later.

After the rotary converter has been brought up to speed there is no difficulty in synchronizing under normal conditions, whether the machine is run from the main bus or from the starting set. If running from the bus, the voltage is correct and the speed can be adjusted exactly by means of the field rheostat. When running from the starting set the voltage can be adjusted to any desired value by means of the field rheostat of the motor generator, and the speed can be adjusted as when running from the bus bars.

In railway substations when after a shutdown the bus is made alive from the third rail, and there are large voltage fluctuations, synchronizing is aided materially by having an extra resistance in the starting circuit which is not short-circuited by the starting switch. Without this resistance the current fluctuates very widely when full speed is reached, making it extremely difficult to synchronize; the addition of a comparatively small resistance to the armature circuit greatly reduces these fluctuations and removes the difficulty mentioned above.

Although the operation of synchronizing is easily and accurately accomplished, under ordinary conditions mistakes are possible. If the machine is being synchronized from the direct-current bus bars when such mistakes are made the results are liable to be serious, possibly wrecking the ma-

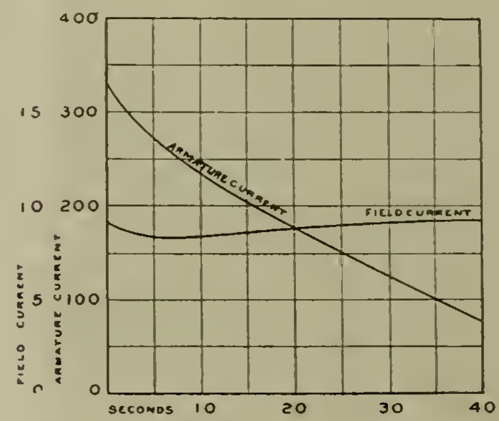


FIG. 3.—STARTING CURRENTS OF A 1500 KW. 600 VOLT ROTARY CONVERTER, SUPPLIED FROM THE BUS-BARS THROUGH 1.8 OHMS RESISTANCE.

chine. If the starting set is used the capacity behind it is so small that the difficulty is almost entirely removed.

Liability to damage at time of synchronizing may be minimized by disconnecting the machine from the source of power before the alternating-current switch is closed. This can be accomplished effectively and with absolute certainty by opening the circuit breaker in the starting circuit by the operation of the control lever of the oil switch on the alternating-current side of the rotary converter. The circuit breaker can be made to act almost instantly, while the oil switch takes an appreciable time before oper-

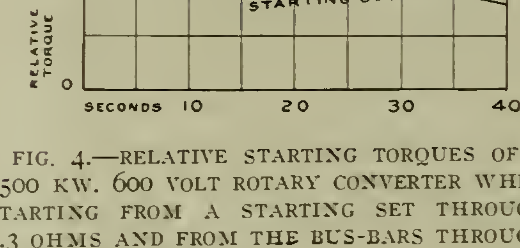


FIG. 4.—RELATIVE STARTING TORQUES OF A 1500 KW. 600 VOLT ROTARY CONVERTER WHEN STARTING FROM A STARTING SET THROUGH 1.3 OHMS AND FROM THE BUS-BARS THROUGH 1.8 OHMS RESISTANCE.

ating. This scheme has been in successful operation in many substations of large capacity.

The Interborough Rapid Transit Co. operates 15 substations containing a total of over 80 1500-kw. three-phase rotary converters. The method of starting is that last described. In seven of these substations the starting sets of 50-kw. capacity are provided, and in eight of the substations the starting sets are of 100-kw. capacity. In all of the stations provision is made for starting from the main direct-current bus bars.

In the stations having 50-kw. motor generators the rotary converters were started for five years from the motor generators. It was found, however, that in case of a shut-down some time could be saved in getting the necessary rotary converters synchronized by starting only the first rotary converter from a starting set and then starting the others from this first one. About two minutes is required, after getting power, to synchronize and connect to the bus bars the first rotary converter and about one and a half minutes for each of the following ones. The direct-current feeders are closed only on order from the power-house. If the starting set is used to start all of the machines its temperature rise becomes so great that the voltage builds up too slowly. At present all of the synchronizing is done from the main bus, except for the first machine, in case of a shut-down.

In the substations having motor generators of 100-kw. capacity all of the starting is done from these sets, the connections for starting from the bus bars being used only often enough to keep the operators in practice. The converters may be started easily with the secondary switches closed.

At very rare intervals operators in substations using the direct-current method of starting report that a rotary converter will not start although they can discover no error in the operations which they have performed, yet later the same rotary converter can be started without difficulty. This is always due to the operators being in too great a hurry, as investigation of the requirements for starting has proved.

In one substation which was equipped with a 50-kw., 750-volt shunt-wound starting set, as well as being provided with double-throw switches to allow of starting from the bus bars, observations were made on a 1500-kw. 600-volt rotary converter, the results of which are shown by the curves of Figs. 1 to 4.

In Fig. 1 is shown the time required for the field current to attain full value. It is to be noticed that this time is very considerable. The impressed voltage was 750 volts as obtained from the starting set and 600 volts as obtained from the main bus, the resistances of the field is 68 ohms and the inductance approximately 370 henries.

Figs. 2 and 3 show the armature and field-currents of the rotary converter for 40 sec. after closing the starting switch on the first notch. Fig. 2 is for starting from the 50-kw. motor generator adjusted for 750 volts at no load, and Fig. 3 is for starting from the bus bars through an extra one-half ohm resistance. The total resistances in the armature circuits were approximately 1.3 ohms and 1.8 ohms respectively, these being the resistances at the first notch in each case.

Fig. 4 shows the relative torques corresponding to Figs. 2 and 3. The torque is proportional to the product of the field and armature currents and this curve is plotted from these products.

It has been found by repeated tests that the curves shown are good average results. The maximum current on the first rush is always approximately 280 amperes when starting from the motor generator, and 330 amperes when starting from the main bus bars through an extra one-half ohm resistance. These 1500-kw. rotary converters cannot be depended upon to start from rest when the product of armature and field current is less than 1700, although after the static friction is overcome the torque necessarily is very small. It is to be seen then that with armature currents of 280 and 330 amperes when starting from the motor generator and main bus bars respectively, the necessary field currents are:

$$\frac{1700}{280} = 6.1 \text{ amperes.}$$

and

$$\frac{1700}{330} = 5.2 \text{ amperes.}$$

This means that, after closing the field circuit, an interval must elapse before closing the armature circuit sufficient to allow the field current to rise to 6.1 amperes for the motor generator method and 5.2 amperes for the method of starting from the main bus bars; these times are approximately 3.2 seconds and 3.5 seconds respectively. (See Fig. 1.)

It is thus evident that, in starting these rotary converters by either method, the armature circuit must not be closed in a shorter time than four seconds after the fields are closed. This interval seems quite considerable to an operator, especially during a shut-down, and is probably the cause of all the failures to start that have been observed.

To sum up, although rotary converters may be started with certainty as induction motors there will always be a considerable and possibly dangerous shock to the system. Although the operation of synchronizing is eliminated, the indeterminate polarity is sure to cause delays in emergencies. The use of a small induction motor attached to the shaft for starting purposes avoids all shock to the system, but the operation of synchronizing is made unflexible by the inability of adjusting independently the speed and voltage of the incoming machine. The starting of rotary converters as direct-current motors from the bus bars or from a starting set of ample capacity has the advantage of the other methods, by combining certainty of starting, absence of shock to the system and perfect flexibility in synchronizing.

An Oscillograph for Demonstration and Testing Purposes

WM. W. CRAWFORD

Engineer, New York Testing Laboratories

THE oscillograph is an instrument for recording, in the form of a curve, rapidly changing conditions in an electric circuit. One use is the determination of the wave forms and phase relations of alternating currents and electromotive forces.

The essential part of the apparatus is the galvanometer, which is of the type shown in Fig. 1. A fine silver or bronze strip, *a a a a*, is stretched over two bridges, *b b*, the two ends of the strip being soldered to the insulated metal blocks, *c c*, and the middle passing around the pulley, *d*. A small plane mirror, *e*, about one millimeter by one-half millimeter in size, is cemented to the strip, and the whole is placed in the field of a powerful electromagnet, in the manner shown.

When the strip is connected in a circuit, by means of the terminals, *c c*, current passes down one section of the strip and up the other. According

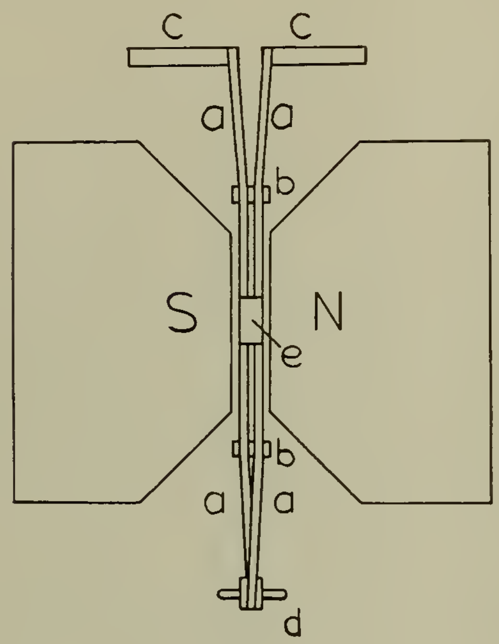


FIG. 1.

to the well-known law for conductors in a magnetic field, the two lengths of strip between the bridges will be pushed in opposite directions, causing the mirror *e* to turn about an axis par-

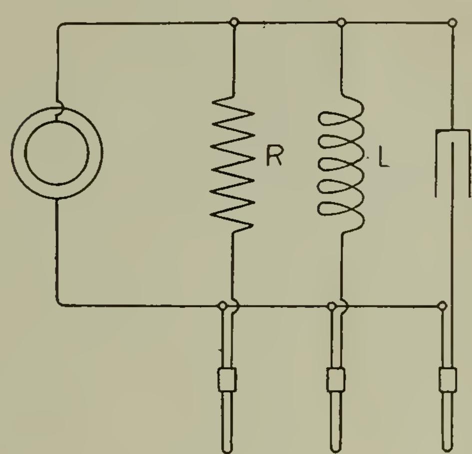


FIG. 2.

allel to the strips. A beam of light thrown on *e* from an arc lamp will be deflected through an angle which, for practical purposes, is proportional to the amount of current flowing in the strip.

It is evident that, on account of the extremely small size of the moving part, the swing of this galvanometer is very quick. In fact, even when the current is varying quite rapidly, as in an alternating-current circuit, the displacement of the beam of light from its zero position, is at each instant proportional to the value of the current.

In order to trace out the variations in the form of a curve, the beam of light is allowed to fall upon a moving photographic film. With this arrangement, of course it is impossible to see the shape of the curve until after the film has been developed. The instrument has, however, an attachment for making the curves directly visible to the eye. This is done by causing the beam of light to reflect from a second mirror, which is made to oscillate by means of a cam on the shaft of a synchronous motor operated from the same source of alternating current as the circuit being tested. A shutter on the motor shaft allows light to pass only when this mirror is moving in a given direction. After reflection from the second mirror, the beam of light has two motions, one an oscillatory motion corresponding to the variations of the current under test, the other a uniform motion in one direction, which is repeated with every revolution of the motor. These two motions are at right angles, and hence combine to make the beam trace, on a screen interposed in its path, the curve of the alternating current. When the frequency is 60 cycles per second, the spot of light moves over the same path on the screen at the rate of 30 times per second. The curve therefore appears as a solid line.

By a suitable arrangement, several galvanometers may be made to throw curves upon the same screen, thus giving simultaneous curves of the currents in two or more circuits. A curve of voltage is obtained by connecting a non-inductive resistance in series with one of the galvanometers, across the line. In current measurements, low resistance shunts are used where the currents are too large to be passed through the galvanometers.

The manner in which the oscillograph may be used to illustrate a point in alternating-current theory was shown at the recent Madison Square Garden electrical show. The three galvanometers of the instrument were connected in series with a resistance, a condenser and an inductance coil, respectively, and all three circuits were connected in parallel to the alternating current terminals of a rotary converter which was driven from the direct current side. Fig. 2 shows the connections. Fig. 3 is a sketch of the curves obtained. The voltage curve *R* was observed to be wavy, due to the presence of a very high frequency electromotive force, an effect due to the commutator. In the current curve for the condenser *C*, these irregularities are exaggerated to a great extent;

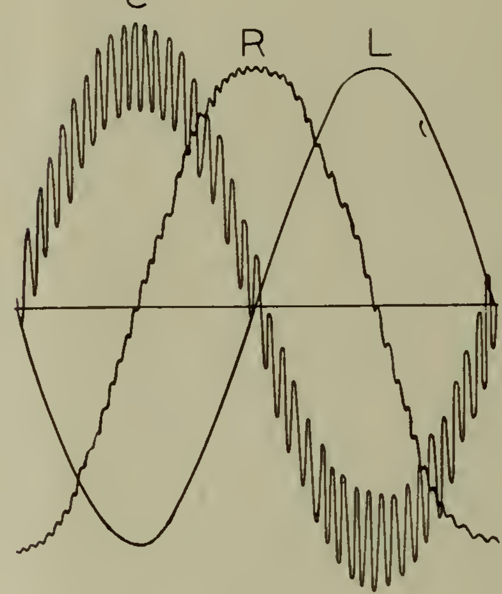


FIG. 3.

in fact, resistance had to be connected in series with the condenser to make the curve smooth enough to be visible. In the current curve for the inductance *L*, these irregularities are choked down to so small a value that they cannot be observed. This demonstrates the fact that for high frequencies, condensers have less impedance, and inductance coils more impedance, than for low frequencies.

The phase relations are shown very clearly, the condenser current leading,

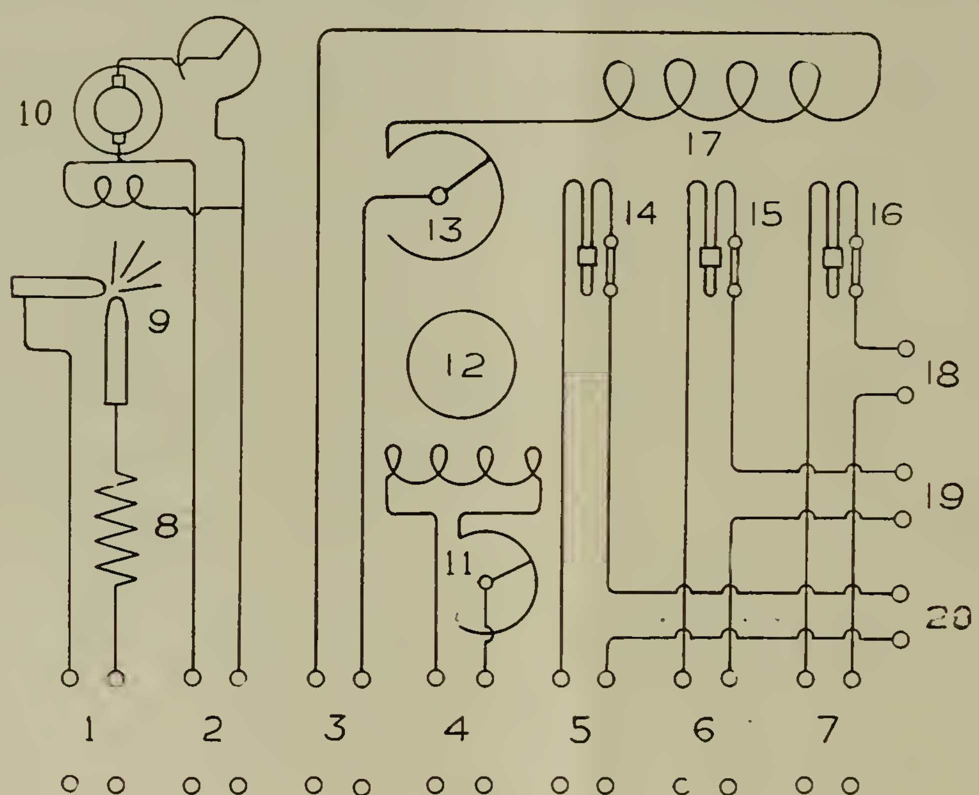


FIG. 4.

and the inductance current lagging with respect to the voltage. The displacement is practically one-quarter cycle in each case.

A few other phenomena which may be demonstrated in the same way are as follows:

Magnetizing current of a transformer.

Phase relations in polyphase circuits.

Current taken by a synchronous motor, with different values of field excitation.

The wiring for making routine tests with this oscillograph is arranged very conveniently. Seven pairs of wires run from the oscillograph table to the laboratory switchboard where, by means of flexible leads, any desired connections may be made. The wiring of the table itself is shown in Fig. 4, the significance of the numbers being as follows:

Switchboard circuit 1 connects to arc lamp 9, through a regulating resistance 8.

Switchboard circuit 2 connects to direct-current motor 10, which is used for driving the moving film when photographs are to made. The speed of the motor is regulated by means of a rheostat in the armature circuit.

Circuit 3 connects to the windings of the galvanometer magnets 17 through a rheostat 13.

Circuit 4 connects to the alternating current synchronous motor 12, through a rheostat 11.

FIG. 5.—APPARATUS SET UP FOR PHOTOGRAPHING THE CURVES.

The three galvanometers, 14, 15 and 16, are connected to the three circuits 5, 6 and 7, terminals being provided at 18, 19 and 20, for the insertion of suitable series resistances in the galvanometer circuits.

The appearance of the apparatus, when set up for photographing the curves, is shown in Fig.5.

The chief merit of the oscillograph lies in the fact that when used photographically it is the only instrument which will record phenomena which takes place only once, or which are different in successive cycles of alternating current. Such phenomena as the pulsation of alternators run in parallel, the abnormal voltages and currents produced by switching and short circuits in high tension systems, etc., are studied with excellent results. While considerable attention has been given, in the foregoing description to the convenient arrangement of circuits used in making tests at the laboratory, it is not to be inferred that the instrument is for laboratory use only. It is, on the contrary, easily portable, and may be set up in any location when tests are desired. It will be of interest to those desiring oscillograph tests, but not having sufficient use for the instrument to warrant its purchase, to know that the one described in this article is at their service at a moderate cost, it being a part of the extensive equipment maintained by the Electrical Testing Laboratories.

The oscillograph described in this article was exhibited in operation at the electrical show recently held in Madison Square Garden. The instrument was manufactured by the General Electric Company.

Single-Phase Electric Motive Power on the Erie Railroad—Rochester Division—*Continued*

W. N. SMITH

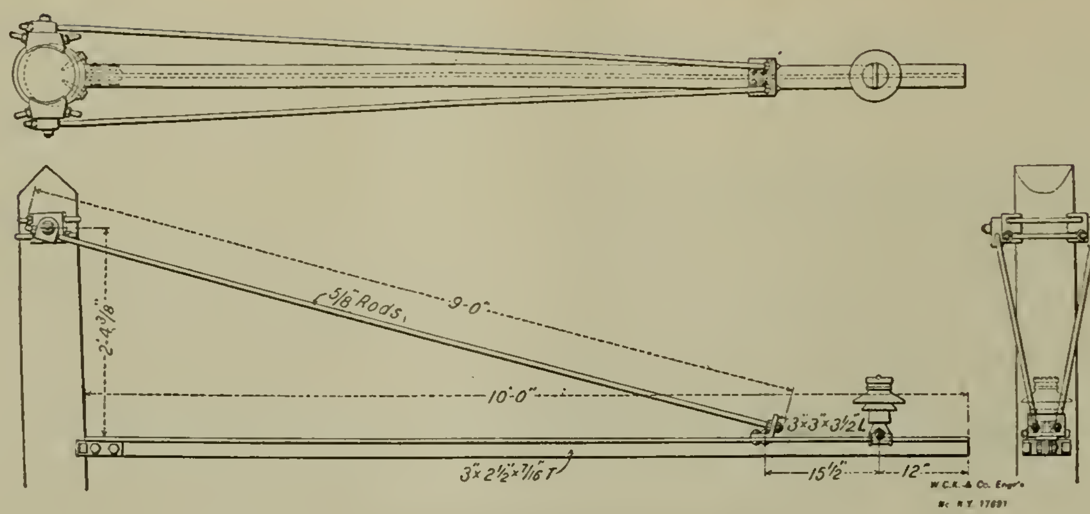
CATENARY TROLLEY CONSTRUCTION.

THE overhead trolley construction is in many respects unique. It was the first of all catenary installations to operate regularly at 11,000 volts. There were very few precedents to follow; many of the details of the overhead work are entirely original, and nearly all of them were especially designed for this installation by the engineers who executed the work.

The poles are of chestnut, averaging 25 in. in circumference at the top, and about 42 in. at the butt. Most of them are about 35 ft. long, but 40-ft. poles were used where the embankments were narrow and steep, and in span construction. Nearly all the construction is of the bracket type, except at the railroad yards at Rochester, Avon and Mt. Morris, and for some distance at Mortimer, where there is a siding on each side of the main track, which prevented the use of bracket construction there.

The poles are given about 12 in. rake. The poles are tamped with cobblestones, of which plenty were available from the coarse gravel with which the road is ballasted. The ground proved very deceptive as regards the nature of the digging, much water-bearing gravel and quicksand being encountered, and oil-barrels had to be resorted to in many instances to prevent caving in of the holes during pole setting.

The brackets are of an entirely original design, each consisting of a 3-in. x 2½-in. tee, 10 ft. long, the heel of which is fastened to the pole by a pair of bent straps, the outer end being supported from the pole top by two ⅝-in. steel truss rods, instead of the single rod commonly used for bracket work. The two rods are attached about 27 in. back from the outer end, run one to each side of the pole and fastened there to a pole clamp devised for this work, which grips the top of the pole instead of requiring the bolt or truss rod to pass through it. In this way the timber of the pole is kept intact and does not have a hole bored through it which will admit moisture and induce rot. The two truss rods are threaded at both ends; at the upper end each one passes through a small iron casting which is in turn carried upon a bolt projecting out from the cast iron portion of the pole clamp, like a trunnion. The whole construction is extremely rigid and is stronger and more conducive to a long life for the pole than any bracket hitherto used. Where necessary, at switches, extra long brackets are employed, the standard brackets being lengthened by splicing; an extra truss rod is attached by means of a clamp to the outer end of such a bracket and run to the extreme top of the pole.



CATENARY TROLLEY BRACKET—ERIE RAILROAD.

The insulator pins are of malleable iron and of a type especially devised for this work. The lower portion of the pin was divided and fitted closely over the flanges of the tee bracket, being provided with a single 5/8-in. bolt by means of which the lower split portion of the pin is clamped securely against the bracket. The brackets and pins were furnished to the engineers' designs by the Electric Service Supplies Co.

The insulator is of the R. Thomas & Sons' manufacture, 6 7/8-in. in diameter and six inches high, made in two parts, but of the three petticoat type, and known as the No. 3029. It was designed by the engineers especially for this installation. As most of the overhead work was done during the winter months and had to be rushed, a quick setting cement of litharge and glycerine was used in place of Portland cement, which not only enabled rapid work in construction but obviated troubles due to the freezing of hydraulic cement while setting.

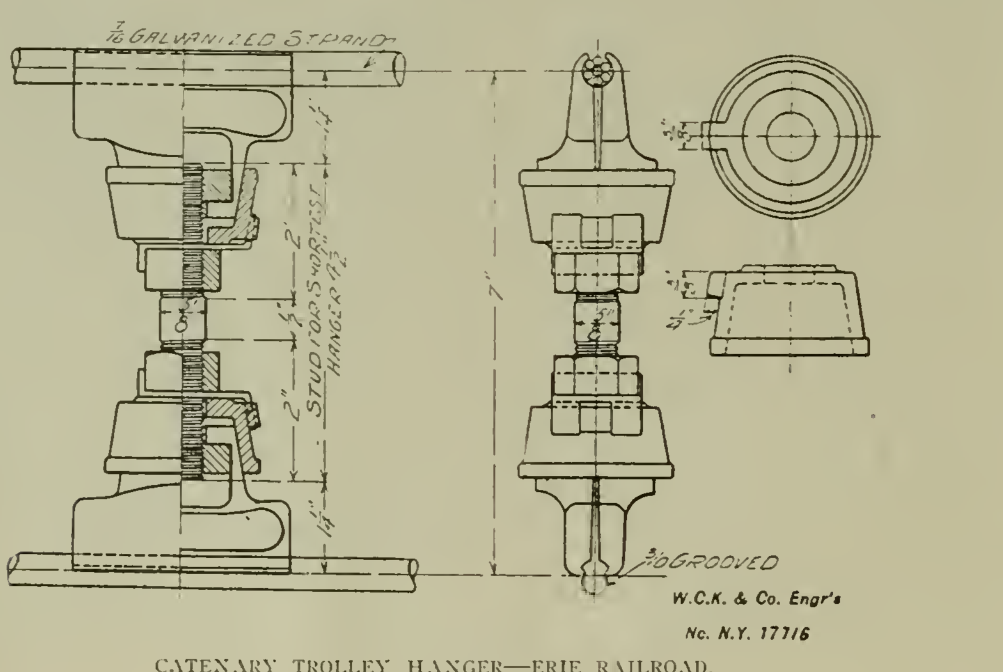
The insulator pins are ordinarily about 12 in. from the end of the bracket but there is 27 1/2 in. space between the end of the bracket and the point where the truss rods support it, which enables sufficient variation in location of insulator to meet most of the requirements in shifting the alignment of the trolley wire on curves.

The messenger wire is of "extra high strength" steel, furnished by the American Steel & Wire Co. It is of seven strands and is 7/16-in. diameter. Joints are made by using the so-called "open" and "closed" cable sockets, the sockets being sweated on to the abutting ends of the cables and joined by a pin connection through the eyes of the sockets. The trolley wire is No. 3/0 B. & S. grooved copper, the lengths being spliced with the usual type of soldered splicing sleeve.

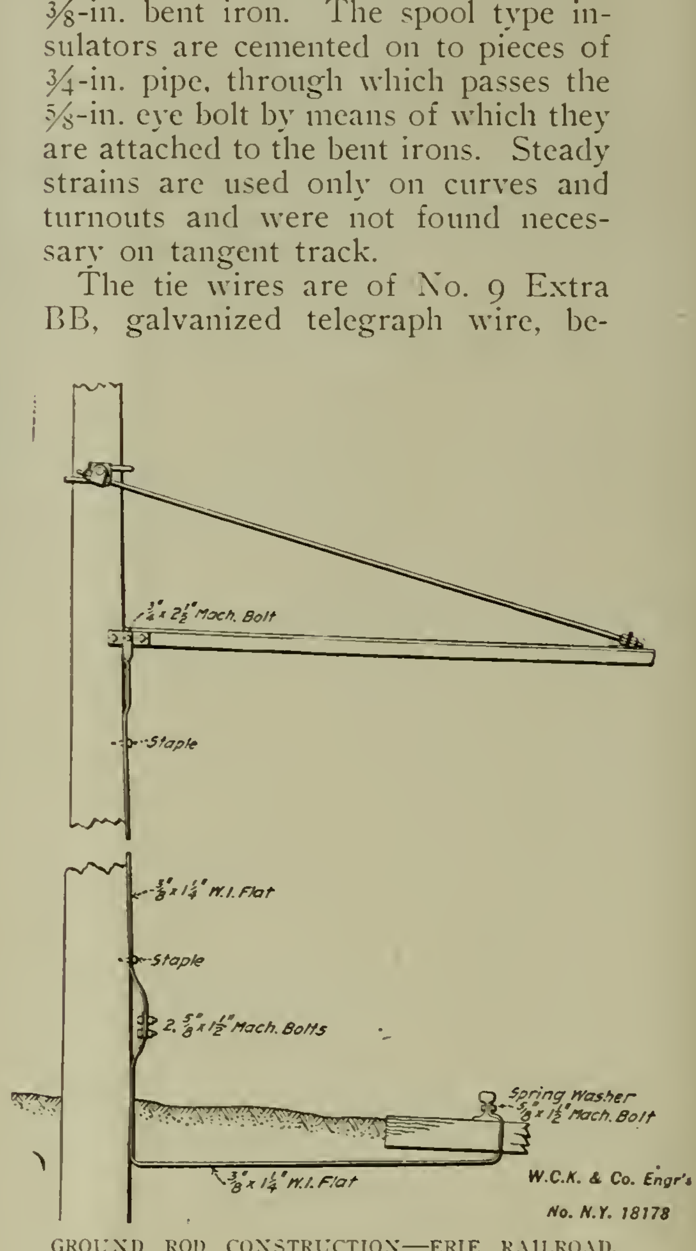
The spans on the straight-line track are 120 ft. in length, and as much shorter than this on curves as required by the radius of the curvature. The maximum deflection from the center line of the track, on curves, is seven inches each way. The catenary hangers were of the Electric Railway Equipment Co.'s drop-forged type, being modified by the engineers to suit the requirements. The messenger clip and the trolley clip are of the same type but grooved differently to accommodate their respective wires. They are joined by a 5/8-in. iron hanger-rod with right-hand threads on each end, the longer rods being flattened in the middle to admit of bending them slightly so as to conform to the divergence of the messenger and trolley wires near the ends of the spans. Both trolley and messenger ears are secured in position by jam nuts. This type of suspension was developed especially for this installation and is so constructed that there is no possibility of parts becoming loose and falling apart on account of vibration. It is also very quickly and easily adjustable on the trolley wires. The hangers are spaced every 10 ft.

The steady strain rods are of treated wood of the Westinghouse Electric & Mfg. Co.'s make and they are mounted at one side of the bracket instead of directly underneath in order to give sufficient clearance for the pantagraph trolley on curves where the super-elevation results in the tilting of the shoe from the horizontal. Each steady strain rod is hinged to a spool-type Thomas porcelain strain insulator which is clamped to one side of the bracket in such a manner that the hinged end of the rod is almost at the elevation of the top of the tee bracket. The method of attaching the steady strain insulators to the bracket is such that they can readily be shifted along the bracket to follow up any change in alignment of the trolley wire that may be required by curvature or for any other reason. The clamps holding the steady strain insulators are of 3-in. x 3/8-in. bent iron. The spool type insulators are cemented on to pieces of 3/4-in. pipe, through which passes the 5/8-in. eye bolt by means of which they are attached to the bent irons. Steady strains are used only on curves and turnouts and were not found necessary on tangent track.

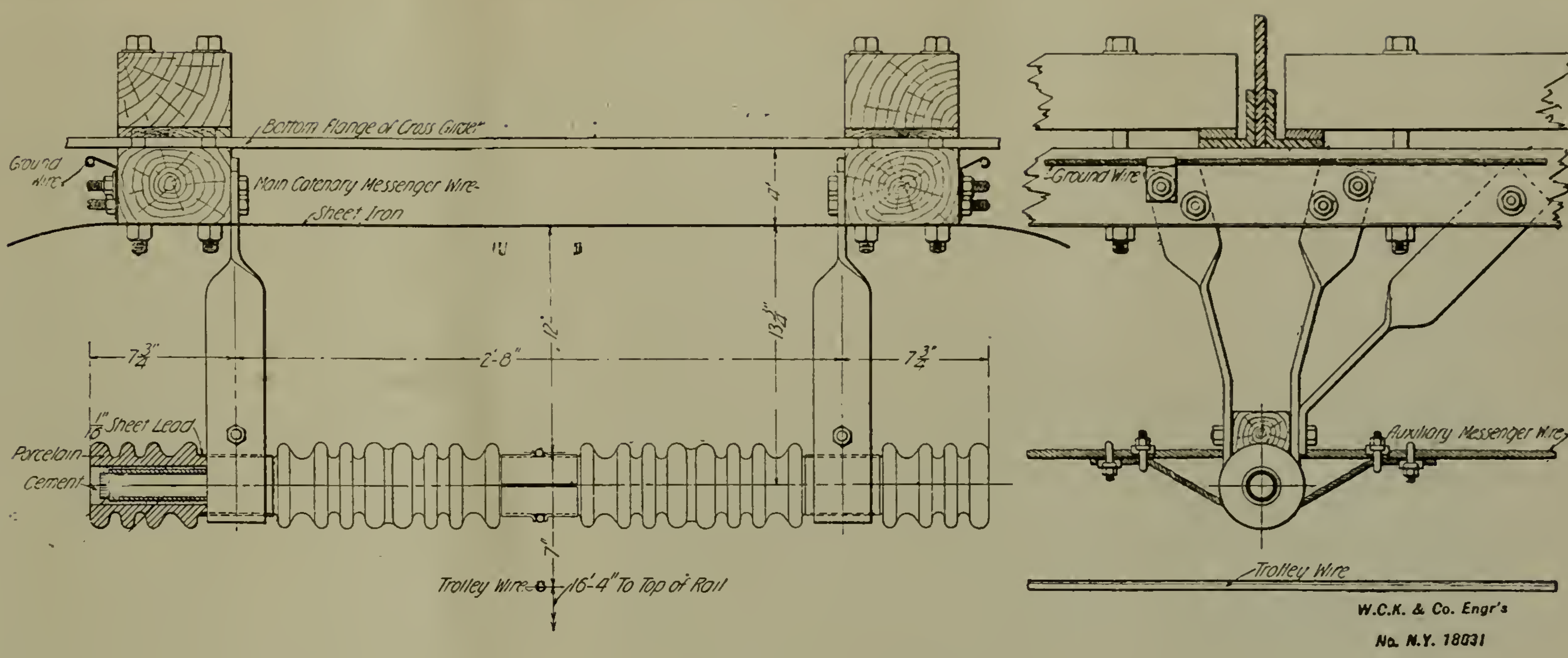
The tie wires are of No. 9 Extra BB, galvanized telegraph wire, be-



CATENARY TROLLEY HANGER—ERIE RAILROAD.



GROUND ROD CONSTRUCTION—ERIE RAILROAD.



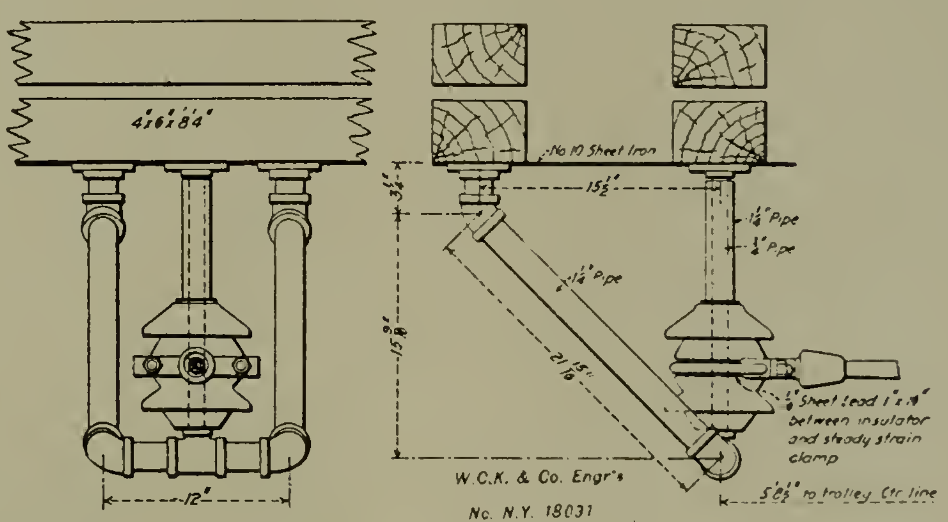
TROLLEY CONSTRUCTION UNDER LOW BRIDGE—ERIE RAILROAD.

cause it was thought best not to make too rigid an attachment between the messenger wire and the insulator; so that if a bracket became detached from the pole for any reason, its weight and the shock of detachment would tear the wire clear from the messenger and allow the bracket to fall entirely away from the wire, thus reducing the chance of steam railroad trains colliding with it. An accident to the electrical equipment of a railway operating both steam and electric trains may shut down the electric service but will not automatically place any check upon the steam service, so that accidents to steam trains must be guarded against as a steam train might easily be wrecked by an obstruction which would automatically prevent power from being supplied to an electric train. This was one of the reasons for installing the system of "ground rods" from the brackets to the rails which is carried out very consistently throughout the installation. Every bracket is grounded to the rail, so that an insulator failure will instantly throw off the power as it will cause a complete metallic short-circuit. There is thus no danger of setting the wooden poles on fire, which would be possible if this precaution were not taken. The burning of a wooden pole would not of itself necessarily cripple the electric service, but it would be quite likely to cause an obstruction dangerous to the passage of steam trains which are of course independent of any disturbances on the electric motive power system. Up to the present time, however, there have been no cases where the overhead construction has caused any obstruction to the passage of the steam traffic.

The ground rods consist of ⅜-in. x 1¼-in. flat steel, their upper and lower ends being bolted to track rail and bracket respectively.

The span construction is as nearly as possible similar to the bracket construction, and uses the same type of pin and insulator. A piece of 3-in. x 2½-in. tee about 30 in. long is suspended from the span wire by hangers of galvanized strand cable, adjustable in length, and fastened to the span-wire cable by specially designed clips, the construction forming a sort of stirrup upon which the pin and insulator are carried. The messenger wire rests upon the insulator just as in the case of regular bracket construction. This form is used not only for spans where there is but one track, but also in the yards at Avon and Rochester where three or four parallel tracks are electrified. Span construction, in general, was only used where conditions absolutely required it.

The Rochester yard was a difficult piece of construction on account of the distance between supports (which reaches a maximum of 94 feet where spanning seven tracks, four of which are electrified), and also on account of the uncertain nature of the soil which on the river bank is filled in with gravel and cinders. For these long spans, where it was impossible to use guys of the usual type (the river bank being on one side and the main highway which gives teams access for loading and unloading of freight cars on the other side), it became necessary to use self-supporting span construction, and this was done by using the "Tripartite" type of steel pole set in concrete. This type of pole, being constructed of re-rolled Bessemer steel rails, is less subject to rust and is consequently more durable than any other available type of metal pole; also all of its surfaces are always open and easy of inspection. On account of the great tensile strength of the material there is considerable saving in weight, and the fact that it was a standardized product enabled quicker delivery to be made than special riveted poles of structural steel shapes especially designed for these locations. The span wires consist of the regular messenger cable fitted with cable sockets sweated on at each end, the same



STEADY STRAIN BRACKET UNDER LOW BRIDGE.

being fastened to turnbuckles and pole collars at the tops of the poles. There are two span cables at each pair of poles; the upper one being used to carry the weight, the lower one acting to steady the arrangement and also to act as a relay in case of an accident to the upper span. Similar construction was also used at Avon, where guying of side poles was not always possible.

PASSENGER TRAIN SHED—ROCHESTER TERMINAL—SHOWING OVERHEAD CONSTRUCTION.

A very simple type of pull-off was devised for curves in span construction, and it so happens that both the Rochester and Mt. Morris yards have considerable curvature. The pull-off consists simply of a spool-type insulator with a piece of pipe cemented through the center; this pipe being slipped over the hanger-spacing rod joining the messenger and trolley clips, thus giving an insulating connection through which an ordinary pull-off cable can be attached to both messenger and trolley wherever required. The division of the horizontal pull between the messenger and trolley wires is easily adjusted to suit the conditions by shifting the spool-type insulator up and down the spacing rod or by inserting longer or shorter nipples of pipe underneath it. In general, when near a span wire, the messenger cable is supported rigidly on its insulator and the trolley wire needs all the side pull; but in the middle of a span, the pull must be equally divided between messenger and trolley wire.

The presence of several through truss bridges over streams and two low bridges over the Erie right of way necessitated the employment of special construction at these points, particularly at the bridges at Clarissa Street, on the outskirts of Rochester. The original clearances here were so low that the road bed had to be excavated and the track lowered about two feet, the minimum clearance between the rails and the trolley wire being finally 18 ft. The messenger is fastened to a horizontal spool-type insulator mounted at the center of a substantial piece of turned oak, which is long enough to carry two more similar insulators, one on either side of the center one.

The steel hangers reaching down from the overhead bridge structure carry the two side insulators, so there are always two insulators in series between the 11,000-volt messenger cable and the steel work of the bridge. These insulated supports are suspended at short intervals from the under side of the steel work of the bridge and are further supplemented by the use of steady strains which prevent any side displacement of the trolley wire. The shortest sizes of hanger spacing rods are used in such places. Where the bridge trusses are high enough to permit it, an iron stirrup like that used in span work is employed which carries the standard form of straight-line insulator, and the regular type of catenary suspension is employed.

At either side of these overhead obstructions, it was necessary to provide warnings for brakemen upon the tops of freight cars as substitutes for the warnings of hanging pieces of rope previously used. In the accompanying photograph is given a view of the Clarissa Street Bridge, showing both the old arrangement of ropes and the new one, for electrified tracks which supplanted it. It will be noted that at this point only one of the two tracks is electrified and freight trains are here obliged by rule to use the unelectrified track; but to insure that the place shall be absolutely safeguarded, the electrified track is fitted with warning signs of the type shown. They consist of the well-known type of horizontal suspended swinging wooden rod, mounted with its axis at an angle, so that it swings up as it is pushed to one side. The pantagraph trolley is fitted with a set of springs on each side, one of which strikes this warning sign a blow as it passes under and instantly throws it to one side. The blow is struck upon a heavy leather strap held taut by a coil spring


ROCHESTER TERMINAL YARD—OVERHEAD CONSTRUCTION—FOUR ELECTRIFIED TRACKS.

of steel wire in tension, the whole contrivance being fastened to the lower half of the pantagraph trolley mechanism so that it is at the right height for striking the warning sign. The swinging rod is mounted upon the pole by means of insulators, effectually preventing any leakage to the ground, even though a car might stand still directly under the sign and make contact with it for an indefinite length of time.

Nearly all the telephone and telegraph wires which cross over the 11,000-volt trolley wire have been put underground, particularly in the case of the leads composed of only a few wires; but where the line is crossed by heavy telephone trunk lines, they have been protected by the basket type of construction, so designed as to effectually prevent a broken telephone wire from falling across the messenger or trolley wire. This consists primarily of four galvanized steel cables stretched between opposite ends of two cross arms, one placed above and the other below the wires of the intersecting telephone line; the four cables are joined by a basket work of light strap iron ribs placed at intervals of three to four feet across the whole span, forming the sides and the bottom of the cradle and effectually preventing a broken telephone wire from dropping any further. This construction was also followed in the case of an electric light line at Avon.

The telegraph department of the railroad company in connection with the signal department constructed a private telephone line of two copper wires between Rochester and Avon with instruments at all signal towers and stations in the dispatcher's office, and at the substations, car shed and master mechanic's office. This telephone system is run upon the trolley bracket poles, transposed every third pole, and has worked satisfactorily.

Lightning protection for high-tension single-phase railway lines not having as yet been standardized, only a part of the line was equipped with line lightning arresters, which are of a swinging fuse gap type of construction made by the Westinghouse Electric & Manufacturing Co. This type of lightning arrester consists of a gap one side of which is connected directly to the trolley through a No. 4 copper wire, the other side being directly connected to the ground rod through a fuse enclosed in a tube which, while the fuse is intact, is maintained in an inclined position like a pendulum held back from its position of rest; but when the fuse is blown, a latch is released which allows the fuse tube to swing to a vertical position which shows conspicuously from the ground and signifies to the patrolman that the fuse should be replaced. The fuse tube can then be lifted off the suspending lugs by a pair of insulating tongs made for the purpose and the fuse renewed and replaced in a few moments.

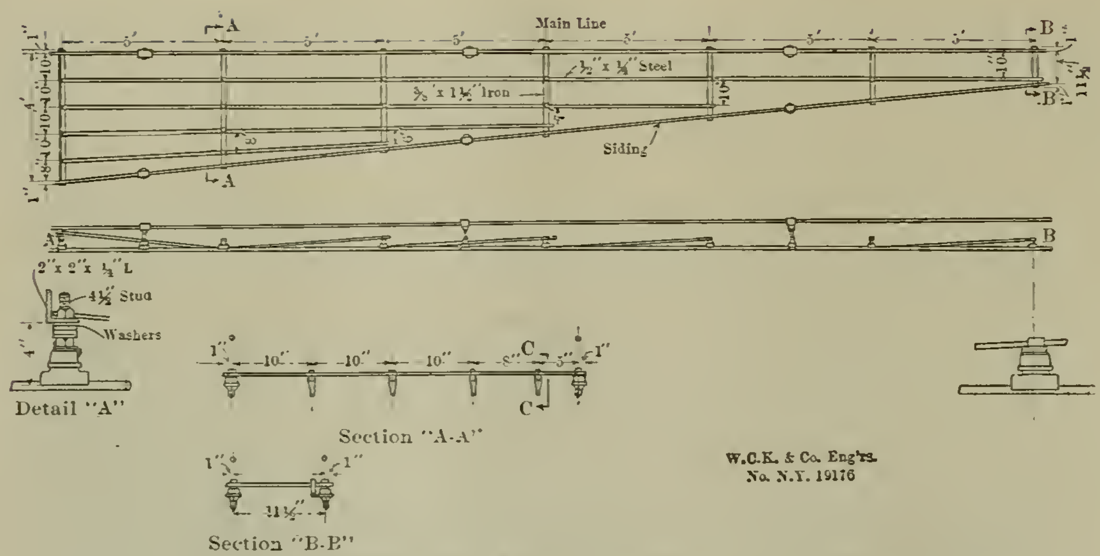
AVON YARD—LOOKING SOUTH TOWARD STATION.

OVERHEAD CONSTRUCTION—MT. MORRIS TERMINAL.

On the other half of the line, lightning arresters were not installed. During the summer, two of the poles were struck by lightning, but the metal work of the brackets and truss rods being entirely grounded, these poles were not damaged below the topmost point of attachment of the truss rods, which is generally not over 18 in. from the top of the pole. In a number of instances several lightning-arrester fuses have blown, but it is not known how many of them have blown simultaneously. Although the extent to which this type of arrester is fully protective is hardly established as yet, it can be stated that at no time since regular operation started has any injury to the car equipment resulted from lightning though there were several severe storms during June and July.

The trolley line is divided into seven sections: One comprising the Rochester terminal, one the Avon yard, three sections in the main line between Rochester and Avon, and two sections south of Avon.

The sections are divided by trolley-section insulators, made by the Westinghouse Electric & Mfg. Co. They are of the overlapping type, made of impregnated wood, and are of sufficient length to insure insulation at 11,000 volts. Each section insulator



DEFLECTOR FOR INTERSECTING TROLLEY WIRES—ERIE RAILROAD.

is carried upon two brackets, mounted on poles spaced 10 ft. apart. As the trolley and messenger must both be completely insulated on opposite sides of the breaker heavy strain insulators were introduced upon which the messenger is dead ended, the two insulators being connected across the gap by a heavy steel rod. This entire combination is supported upon standard insulators mounted upon the regular brackets.

One of the section insulators, that opposite the substation at Avon, is different from the above-mentioned type in that it is not of the overlapping type, it being necessary to absolutely separate the two halves of the trolley line in order to utilize the separate phases of the current in each half of the trolley.

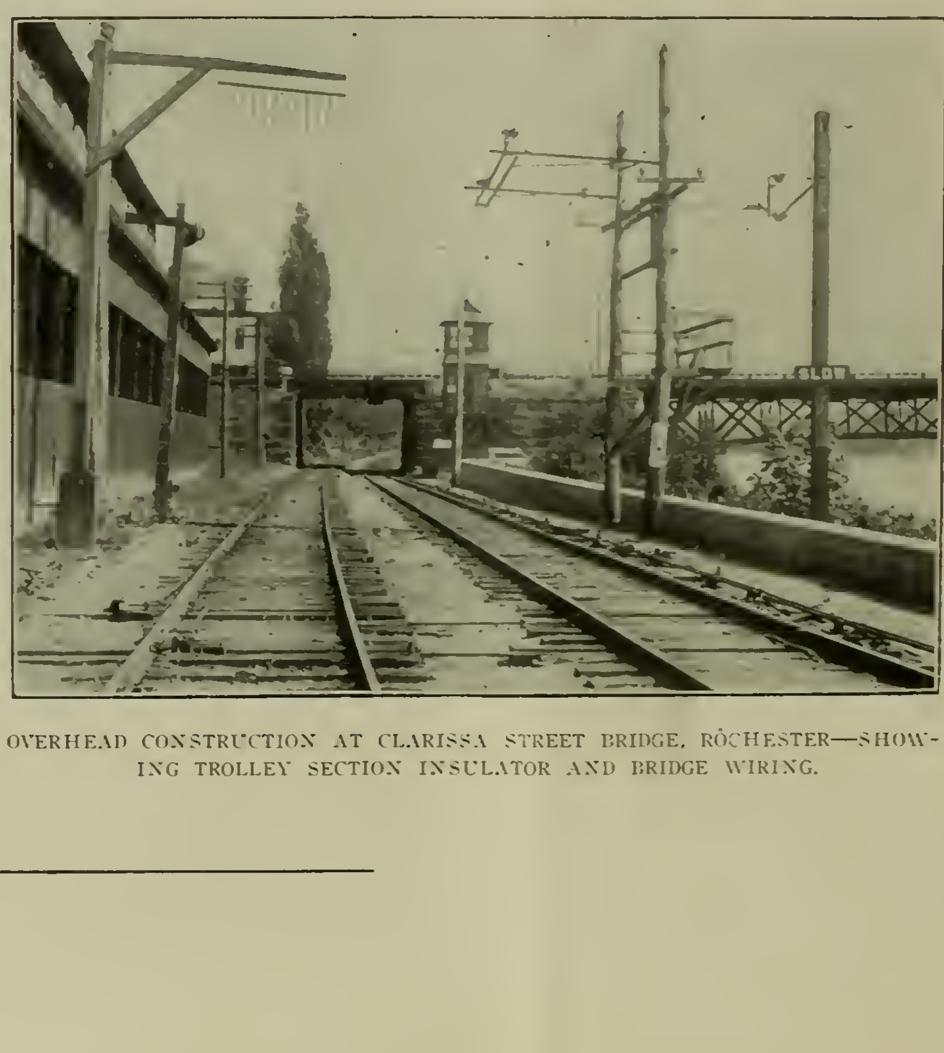
The only feeders necessary are those connecting the substation with the trolley on opposite sides of this section break. The principal object of cutting the trolley into additional sections is to facilitate the locating of line trouble.

The conditions of electric traction upon this line are such that no feeder is necessary besides the trolley wire and consequently there is no necessity for feeding the sections separately. A jumper is therefore provided at each section insulator in which is placed a hook-type knife switch that can be operated in case it is desired to cut out one section. Normally, however, the switches are closed and the effect of the jumpers is to make the trolley wire continuous.

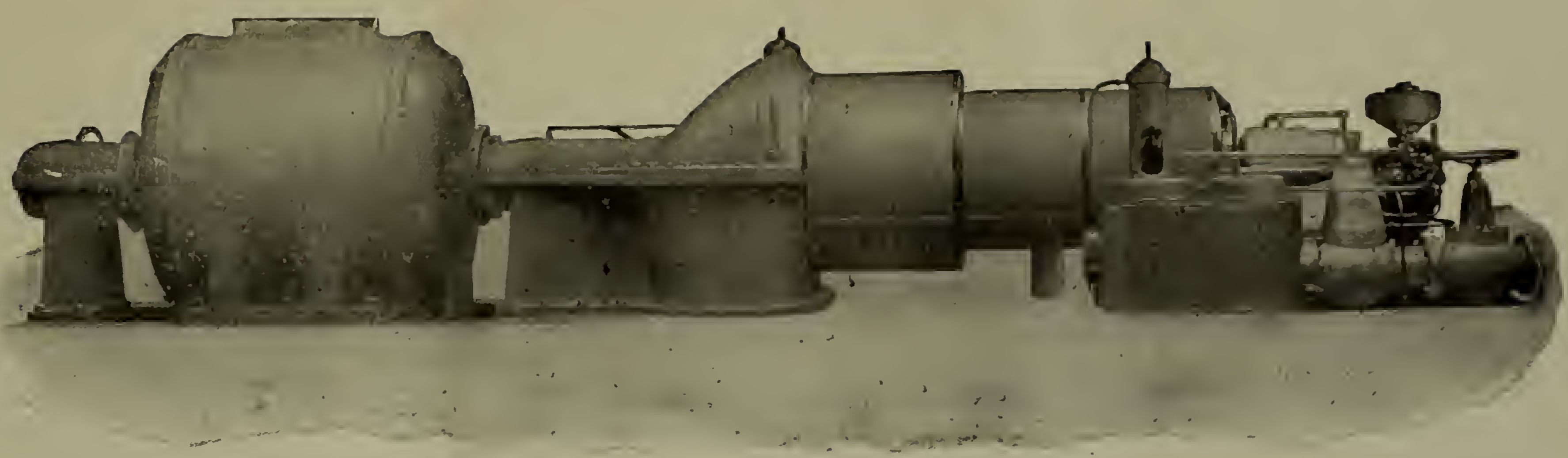
Another detail peculiar to the catenary type of trolley construction is the "deflector"—a sort of mechanical fender placed in the angle formed by the intersecting trolley wires at switches. The type of deflector here used consists of four or five bars of flat steel, ½-in. x ¼-in., suspended by riveted hangers from crossbars spaced five feet apart which in turn rest on standard trolley clamps fastened to the trolley wire. The particular advantage gained by this construction is that no extra tension is needed to keep the bars from sagging and getting crooked, this type of deflector being of minimum weight and entirely self-contained. Deflectors are placed over both angles of each switch. The object of the deflector is to prevent the end of the pantagraph shoe, when traveling under either wire, from becoming hooked over the other wire.

(To be continued).

OVERHEAD BRACKET CONSTRUCTION—MAIN LINE AND SIDING AT WEST HENRIETTA STATION.



OVERHEAD CONSTRUCTION AT CLARISSA STREET BRIDGE, ROCHESTER—SHOWING TROLLEY SECTION INSULATOR AND BRIDGE WIRING.



1500 Kw Allis-Chalmers Steam Turbine and Generator

Allis-Chalmers Steam Turbines and Generators

BRIEFLY stated, steam turbines can be divided into two general types; the impulse type and the reaction type.

In the impulse type the steam, before doing any useful work, is expanded in nozzles of various shapes, its pressure being considerably reduced while it acquires a high velocity before acting upon the revolving buckets or blades. In some constructions there is only one row or ring of revolving buckets and the turbine runs at a very high speed relative to that of the steam, thus necessitating the employment of gearing to reduce the speed to workable limits. In other constructions two or more rows of buckets are used, each of which rows absorbs a part of the high steam velocity, thereby reducing the turbine speed. For the purpose of obtaining a better economy, in the later impulse turbines the steam is passed through several successive sets of nozzles and their subsequent rows of buckets.

In the reaction type the steam acts directly upon the blades without initial reduction in pressure, except such as may be effected by the governor in securing speed regulation. The steam flows through a large number of rows of blades, alternately stationary and revolving. Guided by the stationary blades upon the revolving ones, the steam expands continuously throughout the length of the turbine, alternately gaining velocity and imparting it to the rows of blades, partly by impulse, but to a greater extent by the reaction as it issues from the revolving blades. There is no violent change in pressure at any time; the reduction seldom exceeds three pounds at any one row of blades, and the velocities are therefore comparatively small.

The longitudinal section on page 436 shows the Allis-Chalmers turbine in diagrammatic form, but omits all details which are not necessary to an understanding of the general principles.

The turbine consists essentially of a fixed casing, or cylinder, and a revolving spindle, or drum. The ends of the spindle are extended in the form of a shaft, carried in two bearings, A and B, and, excepting the small parts of the governing mechanism and the oil pump, these bearings are the only rubbing parts in the entire turbine.

Steam enters from the steam pipe at C and passes through the main throttle or regulating valve D, which, as actually constructed, is a balanced valve; this valve being operated by the governor through suitable controlling mechanism.

The steam enters the cylinder through the passage E, and turning to the left (as seen in the cut) passes through alternate stationary and revolving rows of blades, finally emerging from the blades at F and passing through the passage G to the condenser or to the atmosphere, according to whether the turbine is condensing or non-condensing.

Each row of blades, stationary and revolving, extends completely around the turbine, the steam flowing through the full annulus between the spindle and the cylinder. In an ideal turbine the lengths of the blades and the diameter of the spindle which carries them would continuously and gradually increase from the steam inlet to the exhaust. Practically, however, the desired effect is produced by making the spindle in steps, there being generally three such steps or stages, H, J and K.

The blades in each step are arranged in groups of increasing length. At the beginning of each of the larger steps the blades are usually shorter than at the end of the preceding smaller step, the change being made in such a way that the correct relation of blade length to spindle diameter is secured.

The steam, acting as previously described, produces a thrust tending to force the spindle toward the left, as seen in the cut. This thrust, however, is counteracted by the "balance pistons" L, M and Z, which are of the necessary diameter to neutralize the thrust on the spindle steps H, J and K respectively, the pressure on the balance piston at Y being equalized with that on the third stage of the blading at X by means of passages (not shown) through the body of the spindle. In order that each balance piston may have the proper pressure on both sides, equalizing passages O and Q are provided, connecting the balance pistons with the corresponding steps in the blading.

The end-thrust being thus practically neutralized by means of the balance pistons, the spindle "floats," so that it can easily be moved in one direction or the other. In order to definitely fix the position of the spindle a small "thrust bearing" is provided at R inside the housing of the main bearing B. This so-called thrust bearing is adjustable to locate and hold the spindle in such position that there will be such a clearance between the rings of the balance piston and those of the cylinder as will reduce the leakage of steam to a minimum and at the same time prevent actual contact under varying conditions of temperature.

Where the shaft passes out of the cylinder at S and T it is necessary to provide against in-leakage of air or out-leakage of steam. This is accomplished by means of glands which the small scale of the illustration renders it impossible to show as actually constructed. These glands are practically frictionless, being made tight by water packing without metallic contact.

The shaft of the turbine is extended at U and coupled to the shaft of the electric generator by means of a flexible coupling. This coupling is inside of the bearing housing.

The turbines are so proportioned that, when using steam as previously described, they have just enough overload capacity to take care of the ordinary fluctuations of load when controlled by the governor through the valve D, thus insuring maximum economy of steam consumption at approximately the rated load. To provide for greater overloads, the valve V is supplied, to admit steam to an intermediate stage of the turbine; this being the equivalent of the by-pass valve generally used for admitting live steam to the low-pressure cylinder of a compound reciprocating engine. This valve, shown diagramatically in the illustration, is arranged to be operated by the governor or by hand, as the conditions under which the turbine is to work may require, and is, according to circumstances, located either as shown by the illustration, or at another stage of the turbine.

If it were possible to make the rotor of the steam turbine a tight working fit in its cylinder so as to prevent leakage of steam, the high steam economy of the turbine would even more nearly approach the theoretical limit. The high speeds which are essential in the steam turbine, however, preclude any continuous contact between the rotating and stationary parts, except in the well-lubricated bearings. The rubbing of other parts would produce such friction as would more than neutralize the increased steam economy, and would also result in the ripping out of blades.

It is necessary, therefore, to effect a compromise by leaving a clearance between the rotating and stationary parts and allowing the steam to leak through this clearance, but reducing this leakage to the minimum possible. For this reason the tips of the rotating blades just clear the cylinder, and the tips of the stationary blades just clear the surface of the spindle. For the same reason the rings of the labyrinth packing of the balance pistons are not allowed to come into contact. The necessity of permitting a leakage of steam, and at the same time keeping such leakage as small as possible, has an important bearing on the whole design of the turbine, both as to general proportions, mechanical details and methods of construction.

As, due to varying temperatures, there is an appreciable difference in the endwise expansion of the spindle and cylinder, the baffling rings in the low-pressure balance piston are so made as to allow for this difference. The high-pressure end of the spindle being held by the thrust bearing, the difference in expansion manifests itself at the low-pressure end. The labyrinth packing of the high-pressure and intermediate pistons has a small axial and large radial clearance, whereas the labyrinth packing at the low-pressure end has a small radial and large axial clearance.

The Allis-Chalmers method of blading is, briefly, as follows: Each blade is individually formed by special machine tools, so that at its root it is of angular dovetail shape, while at its tip there is a projection.

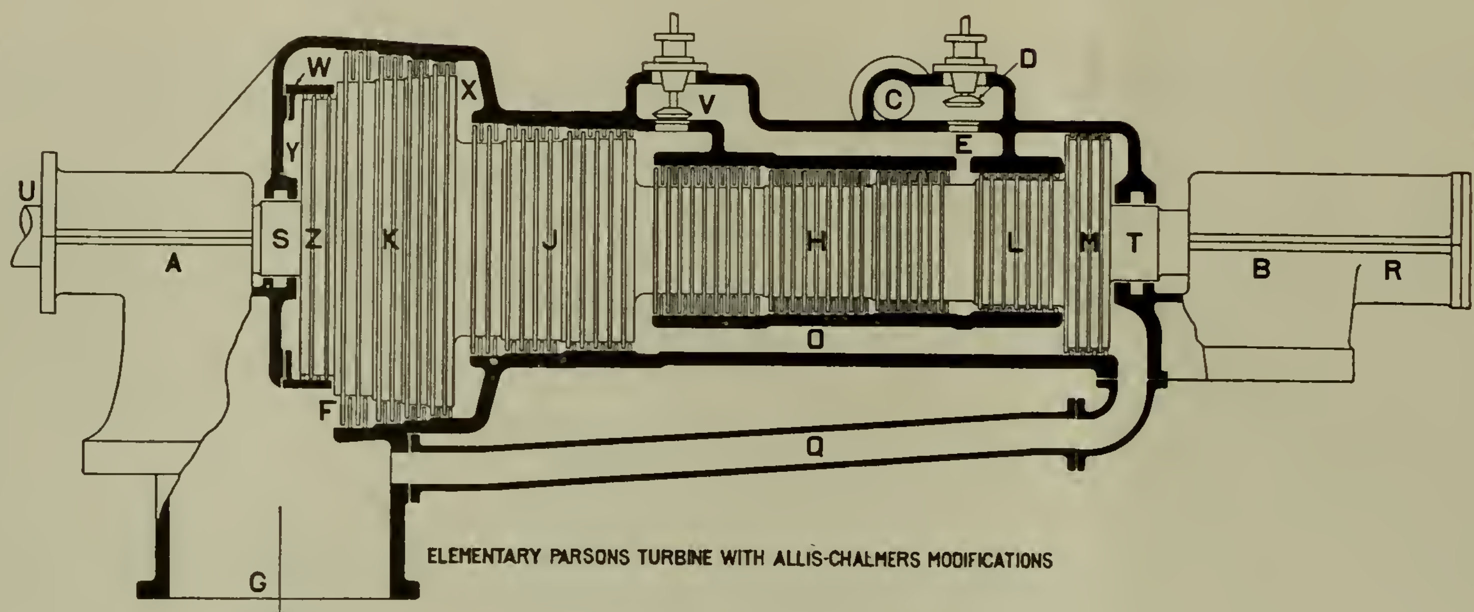
To hold the roots of the blades firmly there is provided a foundation ring, A, see illustration, which, after being formed to a circle of the proper diameter, has slots cut in it by a special milling machine: these slots being formed of dovetail shape to receive the roots of the blades, and at the same time being accurately spaced and inclined to give the required pitch and angle to the blades.

To protect and in a substantial manner bind together the tips of the blades, a shroud ring, B, is used. Holes are punched in the ring to receive the projections on the tips of the blades, these holes being accurately spaced by special machinery to match the slots in the foundation ring.

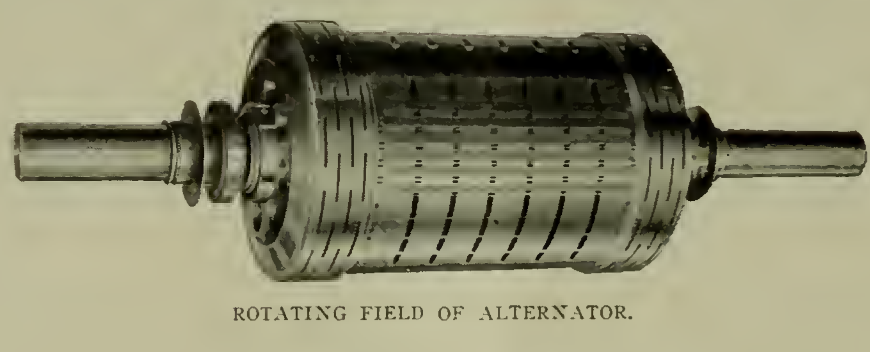
The bearings are of the self-adjusting ball and socket pattern, especially designed for high speed, with as large bearing areas as have been demonstrated by experience to be ample for this purpose. Shims are provided for proper alignment, but are so arranged that they cannot easily be tampered with.

The lubrication of the four bearings, two for the turbine and two for the generator, is effected by supplying an abundance of oil to the middle of each bearing and allowing it to flow out at the ends. The oil is passed through a tubular cooler with water circulation, and pumped back to the bearings.

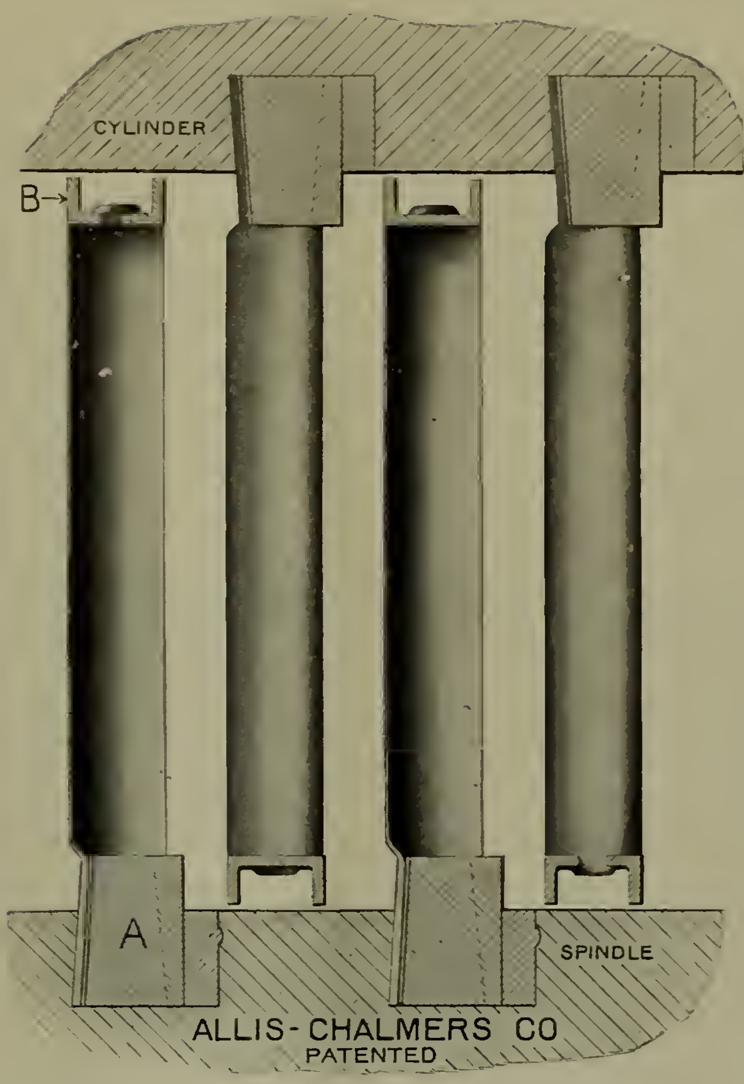
The speed of the turbine is regulated by a governor driven from the turbine shaft by means of cut gears working in an oil bath. The governor operates a balanced throttle valve by means of a relay, except in very small sizes in which the valve is worked direct. The governing mechanism is so proportioned as to respond quickly to variations of load, but at the same time the sensitiveness is kept within such bounds as to secure the best results in the parallel operation of alternators. The governor can be adjusted for speed while the turbine is in operation, thereby facilitating the synchronizing



ELEMENTARY PARSONS TURBINE WITH ALLIS-CHALMERS MODIFICATIONS



ROTATING FIELD OF ALTERNATOR.



REPRODUCTION FROM DRAWING OF METHOD OF BLADING.

of alternators and dividing the load as may be desired.

In order to provide for any possible accidental derangement of the main governing mechanism, an entirely separate safety or over-speed governor is furnished. This governor is driven directly by the turbine shaft without the intervention of gearing, and is so arranged and adjusted that if the turbine should reach a predetermined speed above that for which the main governor is set, the safety governor will come into action and trip a valve, shutting off the steam and stopping the turbine.

The turbines are designed to give their maximum economy at or near the rated load, with only enough overload capacity, under normal operation, to allow for ordinary small fluctuations of load and to permit of good speed regulation. To provide for such overloads as will sometimes occur, an overload or by-pass valve is furnished to admit steam at a later stage in the turbine where the blades are larger than at the beginning, thus enabling the turbine to develop greater power at a slight sacrifice of economy. This valve is operated by the main governor and comes into operation only when the load reaches a higher point than can be attained by the turbine when operating normally.

A steam strainer is provided; perforations are large enough not to obstruct the flow of steam, yet small enough to prevent the passage of almost anything of such size as would damage the turbine blades.

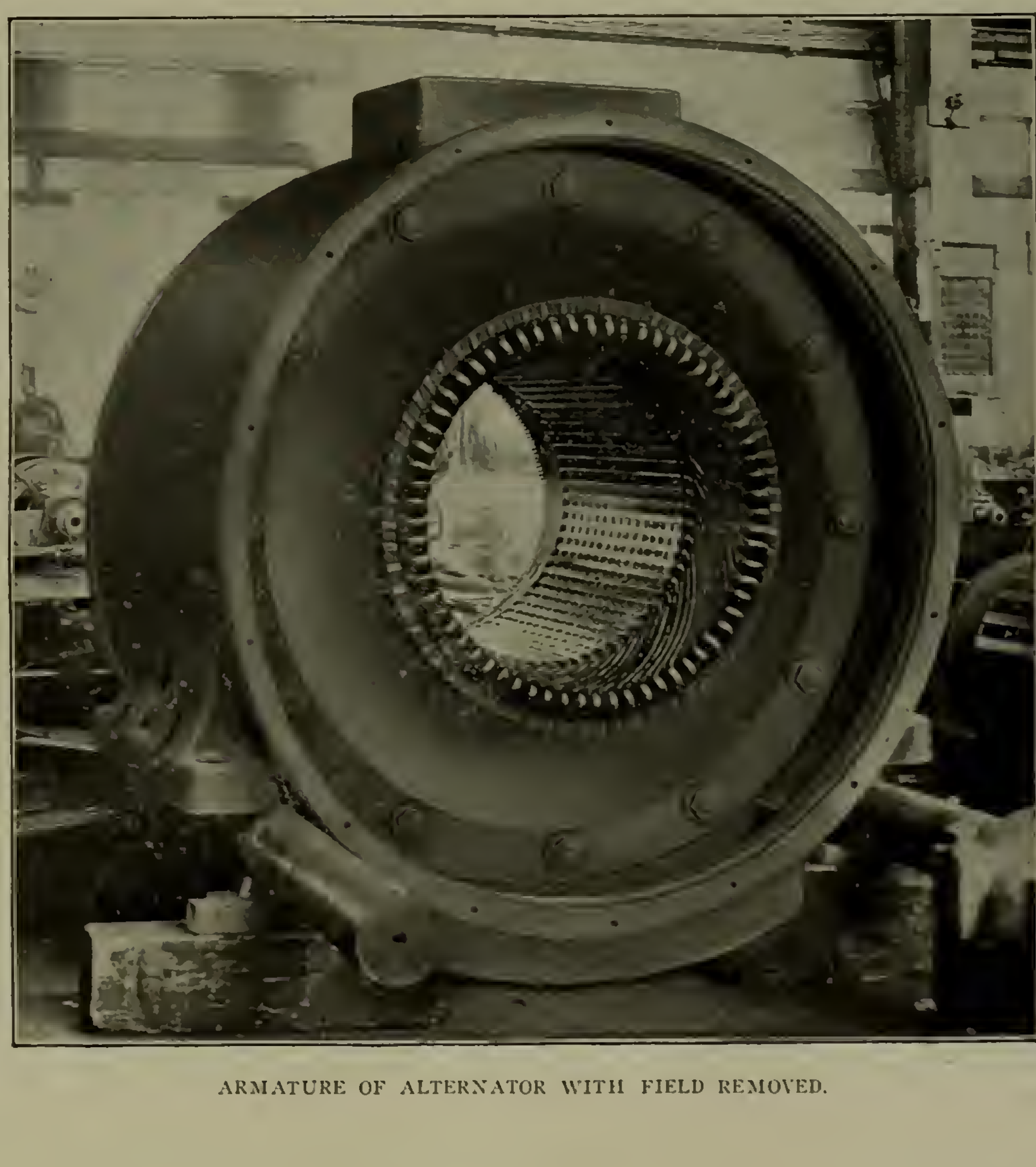
The principal function of the thrust bearing is to locate the turbine spindle accurately in an axial direction, as previously explained. For this reason it is made adjustable, but the wearing surfaces are so large that, when once set, it should not need readjustment even after years of operation. Like the main bearings, it is automatically lubricated by a flood of oil.

For connecting the rotors of the turbine and generator a special type of flexible coupling is used to provide for any slight inequality in the wear of the bearings, to permit axial adjustment of the turbine spindle, and to allow for differences in expansion.

The revolving field alternators, which are directly coupled to the steam turbines, have been carefully designed to meet the special conditions of turbine operation.

The greatest care is taken in the insulation of the armature coils by successive dippings and bakings after the application of the various layers of insulation. The coils are firmly secured in the slots, and particular attention has been paid to the form of the coil ends and the securing of the same in such a way as to prevent deformation in case of a short circuit.

The field cores of the Allis-Chalmers Company's turbo-generators are, according to size and conditions, built up either of steel laminations, or of nickel steel forgings, of high magnetic permeability and great physical strength. A revolving field core, built



ARMATURE OF ALTERNATOR WITH FIELD REMOVED.

up of nickel steel forgings, is shown, from which the substantial construction can readily be appreciated.

The method of winding the field with flat strap copper in radial slots has been made possible by the use of a specially designed forming machine which bends the copper edgewise and gives an increasing spread to each successive turn of the coil. The carefully insulated coils are firmly and substantially held in the slots by means of Parsons manganese bronze wedges. The revolving field is thus formed as a smooth surface cylinder, no matter what the number of poles, thereby reducing the windage loss, besides tending to quiet operation.

Ample spaces are allowed at regular intervals between the laminations or discs of the core, to provide for ventilation of the core itself and of the coils, air being drawn in through openings formed parallel with the axis and discharged at the periphery. The ventilation of the ends of the coils is attained by allowing them to project beyond the ends of the core in such a way that they can be thoroughly cooled; the coils at this point being firmly secured against the effect of centrifugal force by means of nickel steel rings, which form an extension of the core and are provided with openings for the passage of the ventilating air current.

The Pay-As-You-Enter Car.

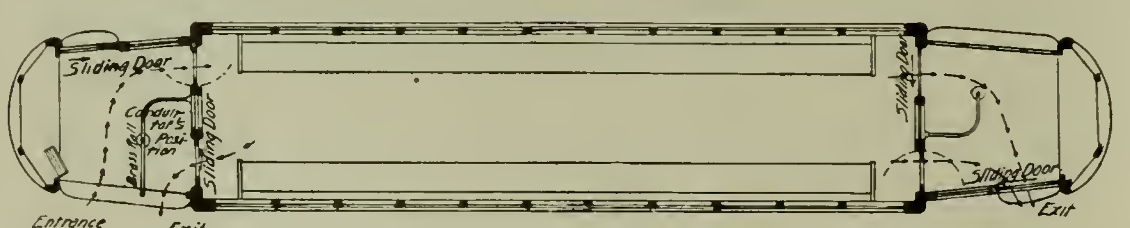
An experiment is about to be made in New York with what is known as the pay-as-you-enter car, a number of which will be placed in service upon the Madison Avenue line some time in December of this year.

The total length of the car is about 48 ft., or about 11 ft. longer than the present standard closed car. The car is also slightly wider than the present standard equipment. For the purpose of greater comfort to passengers, and in order that less time may be consumed in making stops, entrance is restricted to the rear platform, although persons may leave the car at either end; but, as will be seen by referring to the floor plan, the annoying situation created by the attempt of one set of persons to leave the car by the same step as that by which other persons are seeking to board the car at the same time is eliminated. Persons who desire to enter the car may do so at the point marked "entrance," stepping upon a commodious platform seven feet six inches long by approximately six feet broad. They then move in the direction indicated by the arrow, past the conductor, who stands at the point shown, to whom the fare is paid as the passenger enters the car. As soon as all of the passengers have stepped upon the platform (which will hold more than 20 persons) the conductor, who always maintains the same position, gives the signal to the motorman to proceed, and the passengers enter the car from the platform as soon as the fare has been paid. In order that there may be room upon the platform for persons who may board the car at the next stopping place, passengers are not allowed to remain standing upon the rear platform.

GENERAL VIEW OF CAR.

The aisle within the car is about six inches broader than at present, and there will be an unobstructed view both forward and backward along the streets by reason of the fact that plate glass will be placed in the sliding and swinging doors at each end of the car; and glass will also be placed in the stationary portion of the end of the car body between the sliding and swinging doors.

In order to afford ample illumination at night, there will be three rows of incandescent lamps in the ceilings, one row in the center and one on each side ceiling. For the greater convenience of patrons, an experiment will be made with a colored light signal displayed upon the front of the car and indicating by the colors blue, green, yellow, red or white light the destination for which the car is bound.



FLOOR PLAN.

Each car will be driven by four motors and will be equipped with both air-brakes and differential brakes. The electrical equipment of the car has been carefully installed and in a manner in full accord with insurance regulations, especially heavy insulation being adopted and asbestos building lumber being used.

REAR PLATFORM.

GENERAL DATA

Name of Builder	J. G. Brill Co.
Motors	4 GE–80
Controllers	K–27
Resistances	C. G.
Brake Equipment:	
Hand	Sterling
Air	General Elec. Straight Air
Circuit Breakers	M. R. 12
Canopy Switches	M. S. S.
Heating	16 Consolidated Heaters—146 X
Lighting	27 Lamps in all—Five 5-light Circuits
Length over Bumpers	48 ft.
Length over Vestibules	47 ft.
Length over End Panels	32 ft.
Width over Sills	7 ft. 3 in.
Width over Posts	8 ft.
Width over widest part	8 ft. 3¼ in.
Height from Rail to bottom of Sill	31½ in.
Height from Rail to top of Roof	11 ft. 5 in.
Truck Centers	21 ft.
Trucks	Brill No. 27—GE-1
Truck—Wheel Base	4 ft.
Wheels	31 in—Schoen

Exhibit at Jamestown

GENERAL ELECTRIC COMPANY

A PORTION of the General Electric Company's space at Jamestown has been partitioned off for a model electric dining-room and kitchen. The remainder is guarded with a brass rail behind which is arranged a large variety of motor-driven tools and machinery.

VIEW OF EXHIBIT, INCLUDING EXHIBITION SUBSTATION.

The space devoted to the display of the industrial applications of electricity contains an automatic refrigerating plant made by the Automatic Refrigerating Co., of Hartford, Conn. A portion of the rail is filled with the refrigerating liquid. In one corner stands an electrically-wound Seth-Thomas tower clock and near by is an Ingersoll-Temple electric-air rock drill. Among the other machines are a motor-driven sewing machine, blower set, coffee grinder, meat chopper, dough mixer, washing machine, buffer and grinder, and the automatic house pump. All of these devices are operated by General Electric motors.

Adjoining the exhibit space is the substation of the exposition equipped with three 1400-kw. air blast transformers, two 500-kw. rotary converters, three 100-light arc-lamp transformers and the switchboard, all of General Electric make. This station is also equipped with the latest type of remote control, electrically operated oil switches. Power for the exposition is generated in Norfolk, eight miles away, by three 3000-kw. Curtis steam turbine units. This power is generated at a pressure of 11,000 volts and is transmitted at this potential to the substation where it is stepped down for distribution.

INDUSTRIAL APPLICATIONS.

About 45,000 eight candle-power General Electric lamps are used in the decorative lighting of the exposition buildings and grounds, besides a number of 24 and 30-in. searchlights.

James L. Farmer, secretary of the jury of awards, Jamestown Exposition, has notified the General Electric Company that it has been awarded two gold medals and a bronze medal on account of its exhibit at the exposition.

The classification by which the jury was governed in granting the awards limited them to one in each department, while previous expositions have allowed separate awards for each class of materials exhibited. The General Electric Company's exhibits are grouped in three departments: the machinery, the manufactures and liberal arts and mining departments.

A collection of motors applied to various machine tools and other devices has been awarded a gold medal. The arc and incandescent lamps and electric cooking applications exhibited in the departments of manufactures and liberal arts are also awarded a gold medal. The company exhibited a special motor designed particularly for use with an Ingersoll-Temple pneumatic rock drill, and this motor, because of its peculiar adaptation to the special service, was awarded a bronze medal.

The company was also awarded a silver medal for installation of exhibit.

Electric Locomotive—*Continued*

H. L. KIRKER

WE see, then (what you no have doubt already inferred, that moving a wire into and out of the magnetic field cuts the line in the same way that the expansion and contraction of the magnetic field cut them when we start and when we stop the main current. In all cases it is the cutting that induces the current. You will note that the forward direction of the current is accompanied by a clock direction of magnetism. This is easily

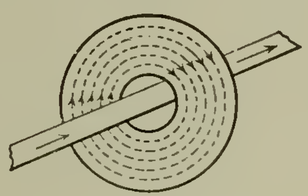


FIG. 12.

remembered, as it is similar to the forward travel and right-hand rotation of a cock screw.

Faraday assumed the current to be encircled by lines of force whose direction, with reference to the current, is the same as the direction of rotation of the cock screw in its forward travel. He discovered that cutting these lines tends to set up a current in the cutting wire, and that the

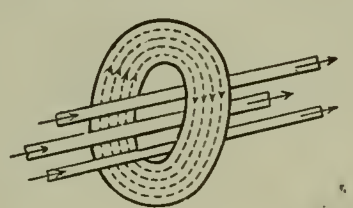


FIG. 13.

direction of the induced current is such as to oppose the cutting. For my own convenience, I have assumed the electric current to be a magnetic vortex whose axis is the conducting wire; and I have assumed that such a vortex can suck in a similar vortex, repel a counter vortex and induce temporary vortexes in conductors that move across the storm area. These general assumptions concerning current and lines of force are easy to carry in mind. We will, accordingly, proceed to apply them to the magnetic circuit.

We have just seen that the electric current is surrounded by a magnetic whirlwind. Let us see if we cannot merge a lot of the little vortexes into one powerful magnetic circuit. We can do this by giving them a more suitable path to travel in than air. Iron is such a path. If we put an iron ring around our current, the magnetic whirls from far and near concentrate in this iron path. The hundreds of lines of force that were uniformly distributed around the wire are now concentrated within the iron ring, and the density of our magnetic circuit in the space occupied by the iron is now hundreds of times greater than that of the surrounding air. The iron has literally corralled the magnetism. See Fig. 12.

If we insert another similar current in this ring, its magnetism will be sucked into the same iron path; the same thing would happen to a third

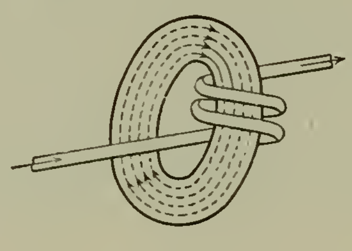


FIG. 14.

current, to a fourth, and so on—all adding their diffused field to the one all-powerful magnetic circuit. See Fig. 13.

It is an easy matter to loop the ends of these wires so as to make a continuous spiral and let one current do all the magnetizing. See Fig. 14.

Now that we have the entire magnetic field in the iron ring we can remove a short segment of the ring and get a dense magnetic field in the corresponding air gap. See Fig. 15. With this dense exposed portion of

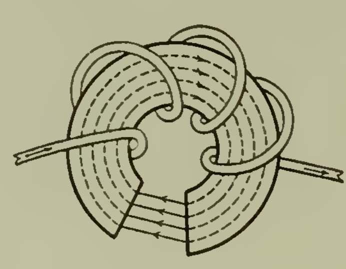


FIG. 15.

the magnetic field we can reproduce on a more powerful scale the induction and motion effects that we have just been considering, for the many turns of the wire distributed over the ring and carrying a small current are but the equivalent of a single wire, carrying a powerful current. See Figs. 12 and 15.

We have, then, in the iron ring and across the air gap a powerful vortex whose axis is the equivalent wire carrying a heavy current along the

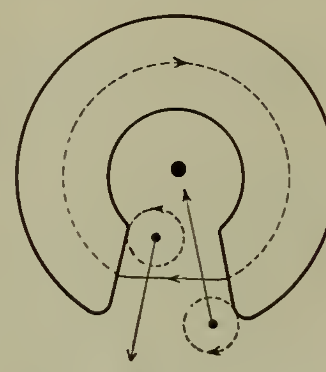


FIG. 16.

axis of the iron ring. If we introduce a current-carrying wire into the air gap of this magnetic circuit, we see that if the vortex around this wire is similar to the main, the wire will be pulled across the air gap toward the axis of the ring. If the direction of the current in the wire is such that the vortex due to this current is counter to the main vortex, the wire will be thrust across the magnetic field away from the axis of the ring. See Fig. 16, also Figs. 4 and 5. A wire then

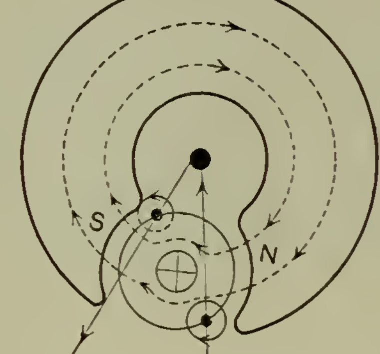


FIG. 17.

carrying a current is in unstable equilibrium when in a magnetic field. The wire tends to move toward or from the axis of the field according to the relative direction of its vortex with reference to that of the main vortex in which it finds itself. We see, then, that we can secure a powerful magnetic field by using an iron circuit and that we can get a dense field in air by removing a short segment of the ring, and that we can make a wire cut across this air gap by sending a current through the wire. The motion is the result of the attraction or repulsion of the vortexes.

(To be continued).

Electric Motor Connections

DIAGRAMS of connections for single-phase electric motors, as made by the Emerson Electric Mfg. Co., are shown below.

Connections for the smallest motors are shown in Fig. 1. In general, this diagram is applicable to motors smaller than one-sixth horse power, the terminals being particularly adapted to the smallest motors.

The larger sizes of motors have terminals as per Fig. 2, though the windings are the same in principle as those of the smallest motors.

Motors of the largest sizes, approximately one-quarter to one-half horse power, have terminals and are connected as per Fig. 3. The winding is here shown for a six-pole machine, which necessitates showing the cut-out outside of the winding for the sake of clearness.

All of these motors operate on the induction principle. In addition to the main winding, an auxiliary phase or starting coil is placed midway between each main coil and also connected in circuit with the line. This auxiliary winding is a modification of the Tesla split-phase winding.

These starting coils exert a strong influence while the motor is starting, and bring the motor up to full speed in a few seconds. The starting coils are automatically open circuited from the line when the armature has attained sufficient speed to dispense with their influence. Thus these coils consume no current except during the period of acceleration.

The device by which these phase or starting coils are disconnected from the circuit is a simple mechanical switch, or automatic cut-out, operating on the centrifugal principle.

Motors equipped simply with this device are not designed to start under full load.

For service demanding a large proportion of the full rated power of the motor in order to start the load, types of motors have been developed which have, in addition to the automatic starting device, an internal centrifugal clutch. The armature is not fastened to the motor shaft, but revolves freely on the shaft without rotating either shaft or pulley. By this arrangement the armature is free to start and attain practically full speed before the load is thrown on. When such a speed is reached that the motor is capable of developing practically full power, the centrifugal clutch engages the shaft, starting the load promptly.

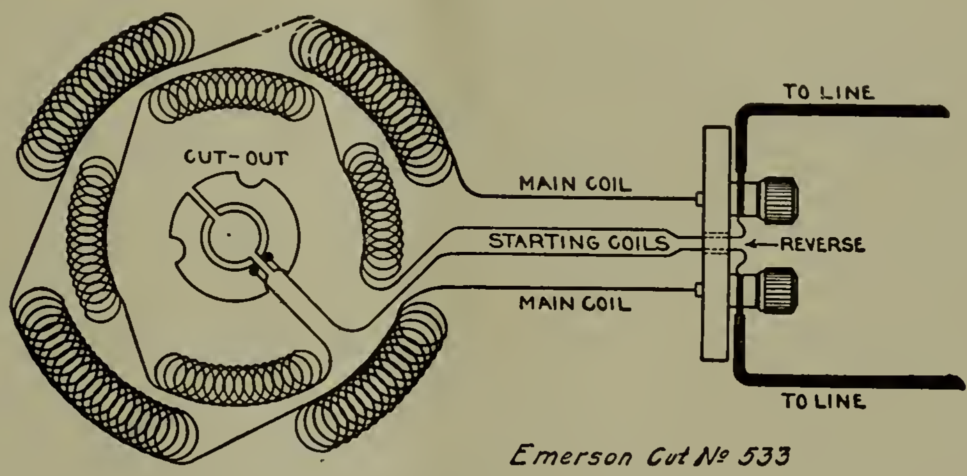


FIG. 1.—USUAL CONNECTIONS FOR MOTORS SMALLER THAN ONE-SIXTH HORSE-POWER.

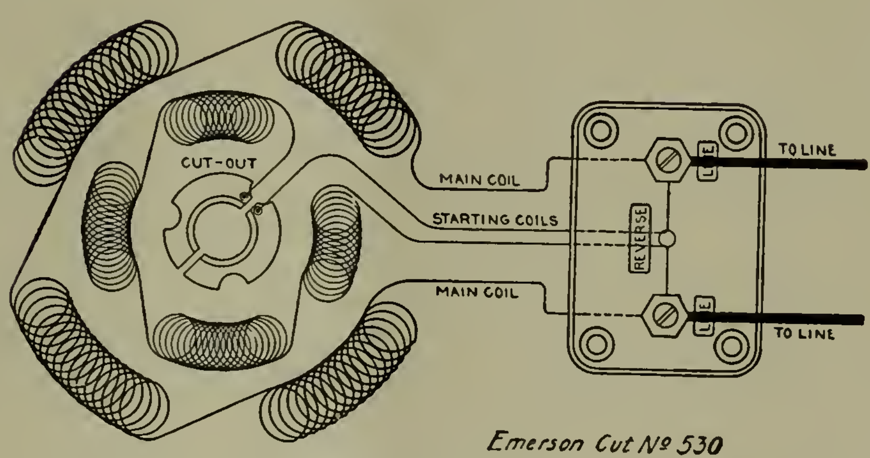


FIG. 2.—USUAL CONNECTIONS FOR MOTORS FROM ONE-SIXTH TO ONE-QUARTER HORSE-POWER.

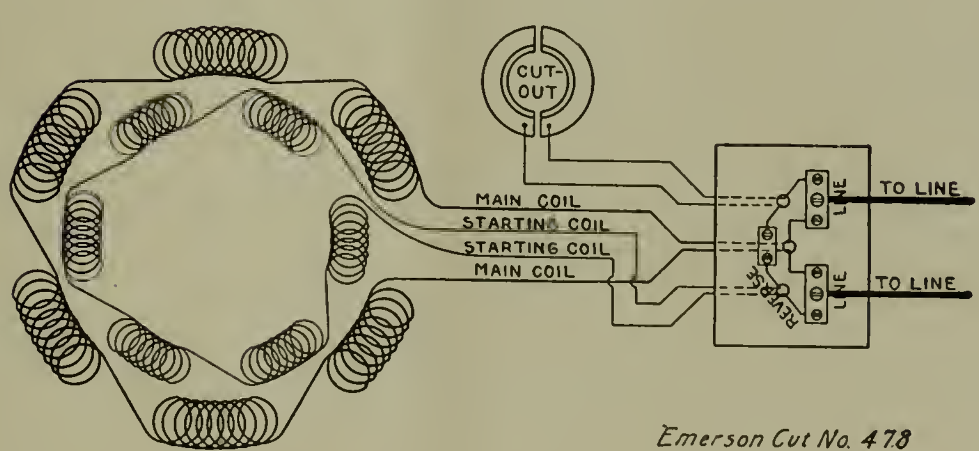


FIG. 3.—USUAL CONNECTIONS FOR MOTORS FROM ONE-QUARTER TO ONE-HALF HORSE-POWER.

SELLING CURRENT

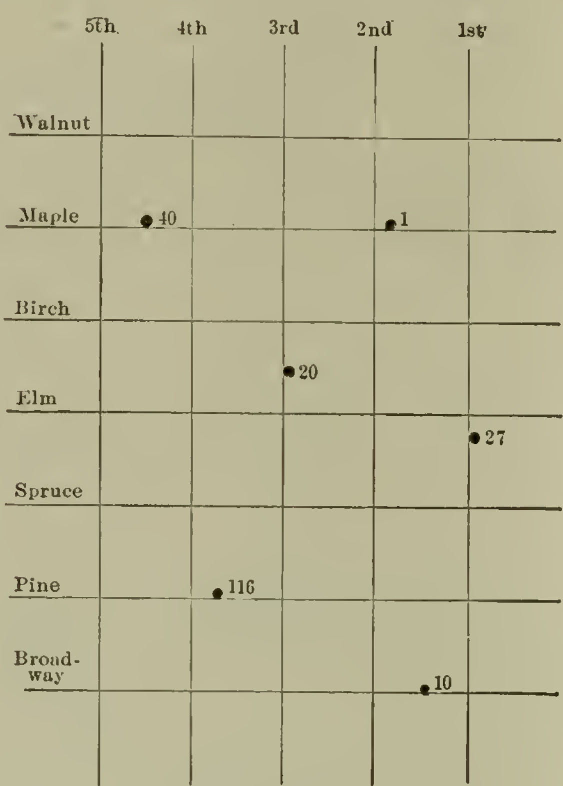
Commercial Experience—*Cont'd.*

C. N. JACKSON.

I would show a load curve taken from the three-wire direct-current system that supplies the business district but for the fact that when you are charging the ready-to-serve plus one cent per kilowatt hour rate you do not care what the load curve looks like. In fact, if you had one that looked like Washington's monument it would not matter, as your profits would all be in the ready-to-serve charge. On the alternating-current system, however, where we handled residences, small stores, saloons, factory lighting, small single-phase power and other such business usually found outside of the business district, the load curve was very important. We handled residences at 12c.; small stores having 20 lamps or less at 10c., with a $2.00 monthly minimum; factory lighting at the same rate, only the minimum was 10c. per lamp; and small power at about 5c. Our load curve in December was peaked. As we were selling nearly all this output at a straight meter rate it was necessary to broaden the load curve. After careful investigation I found that residences and factory business would give the result desired. Consequently our residence solicitors were told to turn in a report on all persons whose houses were wired, but would not take service from our company. To these people I mailed once a week a personal letter; I had about ten of these and the results were phenomenal. It took on an average seven letters to "land" a customer. Too many solicitors get discouraged and quit just before the results begin to show. My policy is to "hang on" as long as I know I have a good argument, no matter what the other fellow says.

One method of getting old residences wired, which I wanted to try but did not have the opportunity, was to furnish four or five months' service *free*, providing the free months fell between February 1st and November 1st. Practically this free service would cost the company a very small amount, as a great deal of the power-station machinery would be idle during this period. The free customers would only increase the expense ¾c. per kw. hr., which would be a small item when you take into consideration a customer gained, and the most profitable customer a central station can have.

I think free renewals should be furnished to residences by all means. They are not like commercial houses who do business in a businesslike way, having someone appointed to look after the lighting equipment, who places an order for a sufficient quantity of lamps to last for several months. The housewife lets a lamp burn until it cannot burn any longer, then asks her husband to stop and buy a lamp. He probably forgets it for a time, until finally he stops at the nearest store and buys anything. We did not furnish free renewals in Toledo, consequently a canvass of several homes showed a few of every make of lamp of all efficiencies and of all degrees of usefulness. We seldom found a lamp that was fit to burn on a 12c. rate, when taking into consideration the fact that lamps burning on a 12c. rate should be of the very highest efficiency—3.1 watts per candle or better. Very few of the lamps had an efficiency better than 5 watts per candle-power and it is not surprising that electricity was considered a luxury.



EXAMPLE OF TRANSFORMER LOCATION MAP.

Often when we receive complaints of high bills and poor light an investigation would show that there were a great number of 32 c. p. lamps in use, nearly burnt out. Customers at the start probably equipped their houses with the proper sizes of lamps, 8 c. p. or 16 c. p. When an 8 c. p. lamp would be nearly burnt out the poor light would be noticed and a lamp of greater power would be purchased, with the result that 32 c. p. lamps would be finally installed.

Even though you furnish free renewals at the office you cannot expect customers to ask for them at the proper time. I believe renewals should be delivered to the homes and installed there. A wagon could make two trips per year, one late in the fall and one in the early spring, at a cost which would not exceed that of keeping a clerk to pass out a few lamps at a time.

The system for keeping transformer records was complete. It consisted of a map of the city. At each location of a transformer a red ink spot was marked, also a serial number. These numbers started with No. 1. On a card numbered to correspond with the number of the location was put the number of the transformer, date of installation, capacity, etc. When we received notice that transformer, say No. 43,774, had been removed from the corner of Pine and 4th Streets, and No. 76,974 had been put in its place, we would look on the map and find the location number, then turn to the card file and pick out the card to correspond to the location number, mark "removed" after the one that was removed, and enter the number of the one installed. A glance at the map would tell where the nearest transformer to a certain spot was located and a glance at the card showed its size.

Location No. 116			
Trans. No.	Date Installed	Capacity	Removed
43774	[illegible]	[illegible]	10 - 05
[illegible]	[illegible] - 05		

TRANSFORMER LOCATION CARD.

The diagrams show a section of a city map and a sample location card.

Suppose one wanted to know where the nearest transformer to 4th and Spruce Streets was located; a look at the map shows No. 116 is the nearest and a glance at the file shows the balance of the information.

Edisison Current for The "New York World"

THE correct adjustment of rates could rarely be better exemplified than by citing the conditions that led to the adoption of the Edison service by the *New York World,* with a statement of relative costs of operation.

Mr. Don C. Seitz, business manager of *The World*, states as follows:

"We have a power plant for operating the presses and supplying light, and it has done this work effectively. However, increased circulation necessitates either enlarging the plant or purchasing current from the outside.

"By making an expenditure of $60,000.00, we could put in a plant to take the additional load and generate current with a saving of one-quarter cent per kilowatt-hour below the Edison rate, due allowance being made for coal, water, supplies, fixed charges, attendance and incidentals. A certain amount of space would be required for the addition, and it is hard to state just what this space will be worth to us in the future. With our present crowded quarters, space is valuable. After the extensive additions to the building now undergoing construction are completed, we will be better able to handle our increased business.

"The main reason for taking the Edison current exclusively is to eliminate the heat and dirt. The chimney runs through the central part of the building, and the heat in the offices near it is undesirable in summer.

"Rates for current will be the same as supplied to all large power customers, three cents per kilowatt-hour with a minimum of $25,000.00 per year. As I said before, with our steady day and night load we can better this by one-quarter cent.

"We shall keep our present plant, and may operate the lighting by this means.

"The power equipment is as follows:

5 sextuple presses, 85-h.p. motor each.

3 quadruple presses, 60-h.p. motor each.

3 octuple presses, 85-h.p. motor each.

2 double-octuple presses, 120-h.p. motor each.

2 sextuple color presses, 85-h.p. motor each.

67 linotype machines, 0.25-h.p. motor each.

9 elevators, 60-h.p. motor each.

"These elevators are of the new traction type.

"There are five pumps taking from 40 to 60 h.p. and two air compressors of 15 h.p. each. We also have some small power in the electrotype plant.

"The lighting equipment consists of 2300 incandescents.

"Our average run is 1,500,000 eight-page papers per day with this plant."

Questions and Answers

No. 1005.—*I am electrician for a large manufacturing establishment. We have a number of motors, all running well except one. It is a motor driving a machine lathe shaft. Voltage is 220 direct, and capacity five horse power. It seems to start to spark in one place, the sparking gets worse every day until I sandpaper it, then it will run all right for a time. The voltage test between commutator bars shows the winding and connections are in good shape.* X. Y. Z.

The fact that after you sandpaper the armature there is no sparking shows that something is wrong with the commutator. The trouble is probably due to the mica insulation between commutator bars being so hard that it does not wear at the same rate as the copper. You should get a grinding brick and keep it for this commutator only. You can chip it away to match the commutator and it will soon wear down so that it fits the commutator exactly. After that there should be no more trouble than an occasional grinding, about once per month.

No. 1006.—*Why do the fire-underwriter inspectors prohibit the use of open-link fuse blocks, even when there is nothing to catch fire when the fuse blows?* Subscriber.

The principal reason for not allowing the open-link fuse block is on account of the liability of the melted fuses gradually forming a metallic path between the terminals. In case a path of this nature should be formed, the fuse would become inoperative.

No. 1007.—*I am street car inspector for ——— company and test from 10 to 15 cars every day. One of the tests is to measure the resistance of different controller notches. Sometimes the resistance is so high the testing set will not measure it, but the car runs all right. There can be no mistake in connections, for the same thing happens frequently. The set measures up to 30 ohms and the car does not start on 17 amperes.*

Inspector.

You have left out the most important part of the information in your letter, the kind of testing set you use. The trouble is, however, of frequent occurrence, and is due to dirt on the commutator under the brush. This dirt gives a high resistance when measured with a low voltage. Even when full voltage is used in making the test, the resistance of the testing set adds enough to prevent the motor from turning. When the full voltage is applied and the set is not in circuit, enough current flows to start the motor turning until better contact is made, then the armature momentum carries it past the black spots.

No. 1008.—*Do long ammeter leads on an alternating-current ammeter affect its accuracy? I want to move our series transformers, but am told that the ammeters will not be as accurate. Do not the series transformers change the current only, and does the voltage drop in ammeter leads have anything to do with it?*

Switchboard Operator.

Answering your first question first, the allowable length of ammeter leads depends on whether you have a wattmeter or any other instrument connected to the same transformer, if not, then you may make the leads as long as you will probably require. In answer to your second question, the voltage drop in the leads affects the reading in the same way as current affects voltage transformers, by increasing the load. The series transformers are made to transform the current in accurate ratio with a given load; if this load be increased they become inaccurate.

No. 1009.—*We have a mixed lighting load on our plant, consisting of both arc and incandescent lamps. Our regular orders are to allow two arc lamps or 20 incandescent lamps per kilowatt of transformer capacity. One transformer of one kilowatt capacity will carry 20 incandescents without trouble, but where we have two arc lamps on a transformer of the same size the fuse frequently blows. I asked the arc lamp man about this, and he said the arc lamps only take 450 watts. Please let me know whether the current in the magnets do not increase the current for arc lamps?* Anderson.

Alternating-current arc lamps take more current than incandescent lamps of the same kilowatt capacity. Allow six amperes for each arc lamp and figure your load from this basis. Sometimes the arc lamps will not pick up as they should at starting and will draw from 10 to 15 amperes each.

Review of the Technical Press

The Relative Merits of Direct and Indirect Lighting

J. S. DOW.

(The Illuminating Engineer, October, 1907, p. 588.)

Advantages of direct and indirect lighting for different rooms and buildings are discussed. Each scheme is recommended for some particular class of work.

Notes on the Use of Low-Pressure Steam in Connection with Engine Exhaust

J. R. BIBBINS.

(The Electric Journal, October, 1907, p. 560.)

In view of the possible development of low-pressure steam turbine work, which seems probable, judging from present indications, a brief discussion of some of the important technical points involved may be of interest. First, consider how much energy is available in steam below atmospheric pressure; second, what percentage of this is transformed into work by the turbine; and third, what percentage by a good steam engine.

The accompanying pressure-volume and pressure-energy curves are based on one pound weight of steam working between 165 lb. absolute pressure and 28 in. vacuum. A theoretical compound indicator card has been sketched in to show, first, how small a part of the total expansion energy of the steam cycle is used in a compound engine running condensing, and second, the relative greater value of high vacuum to the turbine. If properly designed for its work, a turbine is capable of expanding steam right down to condenser pressure, while a steam engine rarely releases below seven pounds absolute.

There is available below atmosphere in the adiabatic steam cycle 49 per cent. of the total energy of the cycle between these particular limits.

Of this 49 per cent., the turbine is able to utilize for useful work, practically two-thirds, and the steam engine from one-fifth to one-third. Operating between 15 lb. absolute and 26 in. vacuum, the steam consumption of a well-designed steam turbine should be under 35 lb. per brake h.p. Now the heat energy released in adiabatic expansion between the above limits, is 113.7 B.t.u. per pound, or $113.7\times778=88\ 500$ ft. lb. as shown by the energy curve. For a steam consumption of 35 lb. per h.p. hr., the steam thus supplies to the turbine 3,097,500 ft. lb. per hour. As one horse power is equivalent to 1,980,000 ft. lb. per hour ($33{,}000\times60$) the turbine actually uses 63.9 per cent. of the available energy in the steam cycle.

The method of connecting the low-pressure turbine to a non-condensing compound engine yields three times more additional power than is obtained by running the same compound engine condensing.

Concrete Transmission Towers

(Electric Traction Weekly, October 3, 1907, p. 942.)

A description of two large reinforced concrete towers for carrying the transmission lines of The West Penn Railways Company transmission lines across the Monongahela River at Brownsville, Pa. The line is 1014 ft. in length across the river and the clearance 80 ft. It consists of 16 cables, one of the feeders being for 22,000 volts.

Piping and Power Station Systems —LVI

W. L. MORRIS, M. E.

(Electric Railway Review, October 5, 1907, p. 410.)

This number takes up the piping for blowing out electrical apparatus. A vacuum cleaner is recommended for cleaning floors, as the collection of dirt on electrical apparatus is thereby avoided.

Line Construction with Data on Costs—II

E. P. ROBERTS AND J. C. GILLETTE.

(Electric Traction Weekly, October 10, 1907, p. 972.)

In this instalment, catenary construction both for low voltage direct current and high voltage alternating current is discussed. The article is profusely illustrated by half-tone illustrations and line cuts. Costs are given for single and double track construction.

An Aerial Electrically Operated Tramway Over Lake Michigan

(Western Electrician, October 12, 1907, p. 283.)

A description of an aerial tramway built under the direction of Mr. George W. Jackson. The tramway is about one and one-half miles long. The traction sheave is driven from a shaft belt connected through reduction gearing to a 25 h.p. induction motor.

The towers reach 30 ft. above the water line and are spaced 300 ft. apart. The last tower is in 30 ft. of water.

Three Ingersoll-Rand air compressor units are being installed. The compressors are belt-connected to three 150-h.p. induction motors.

The Field for Electricity on Steam Railways

FREDERICK DARLINGTON.

(The Railway Age, October 18, 1907, p. 527.)

The advantages to be derived from electrification of steam railroads are ably set forth, with data obtained from actual results. The following paragraphs are taken from the article.

The total operating expense per car-mile of electric interurban roads is usually about 13 to 16 cents. The cost of operating steam railroads per passenger train-mile is usually from four to eight times as much, and the steam motive power cost alone, that is, the steam locomotive fuel, labor, materials and repairs, is ordinarily two or three times as much per locomotive mile as the total operating expense of electric roads per car-mile.

The following table shows the operating expense, including taxes, per car-mile, for several electric railways in Massachusetts, Connecticut and New York, as reported by the railroad commissioners of the various States; also the same table shows the cost of electric power on these various systems:

Name of Road	Total operating expenses per car-mile, including taxes and electric power, cents.	Cost of electric power per car-mile. cents
Warren Brookfield & Spencer	11.7	3.03
Brockton & Plymouth	14.8	2.63
Blue Hill	16.5	3.63
Connecticut Valley	13.0	3.66
Consolidated Railway Company	15.8	2.35
Connecticut Railway & Lighting Co	15.93	2.35
International Railway Co. (Buffalo)	16.00	1.70
Schenectady Railway Company	18.30	2.80

The total operating expense of these various electric roads is in the neighborhood of 16 cents per car-mile. The electric power on the same roads cost about 2 to 3 cents per car-mile.

Kendall Gold Mining Fly-wheel Motor-Generator Set

H. H. CLARK.

(General Electric Review, September, 1907, p. 140.)

The following is a brief description of a unique and interesting electrical hoisting equipment recently built by the General Electric Co., for the Kendall Gold Mining Co., of Kendall, Mont. The requirements which this outfit had to meet were similar to those encountered in most mine hoist installations.

This hoisting equipment was designed to raise 2000 lb. of ore from a 1000 ft. level every 103 seconds when operating two drums, and every 170 seconds when a single drum only was in operation.

The mine shaft has two compartments, and extends vertically to a depth of 1000 ft. Two cylindrical drums are used, which are provided with the usual clutches for individual and combined running, each drum operating a compartment in which the weight of the rope is always balanced by an individual tail rope, whether the other compartment is working or not. This rope is one inch in diameter, and weighs 1.6 lb. per foot, the hoisting speed being 1000 ft. per minute. Each compartment is supplied with one skip weighing 1400 lb., and having a capacity of 2000 lb. of ore.

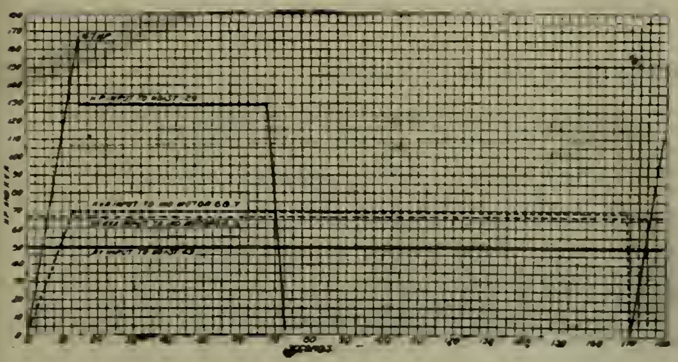


FIG. 1.—HORSE-POWER INPUT. UNBALANCED OPERATION.

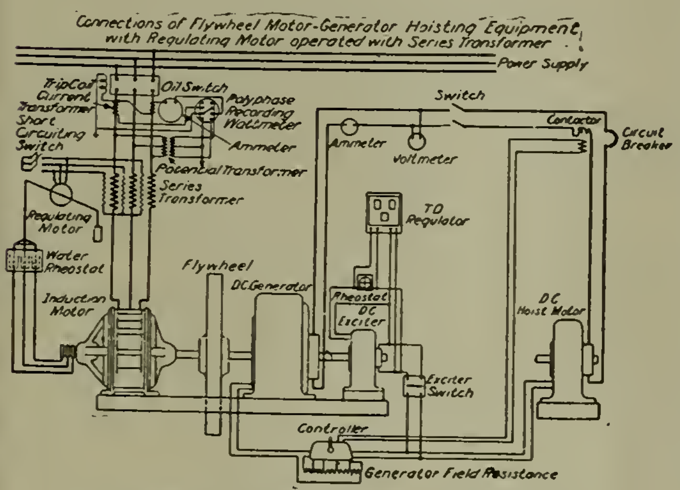


DIAGRAM OF CONNECTIONS OF FLYWHEEL MOTOR-GENERATOR HOISTING EQUIPMENT.

Figs. 1 and 2 show the theoretical curves of horse power input to the hoist, both when running one compartment (unbalanced operation), and two compartments (balanced operation). From these curves the unusual demand which occurs during the period of acceleration is made very apparent.

The capacity of the generating station being somewhat limited, the large rush of current incident to starting and accelerating the hoist tends to produce undesirable voltage fluctuations in the system, and the equipment here described was designed to eliminate this trouble and improve the regulation of the line.

The hoist equipment comprises a shunt-wound direct-current motor, arranged to be geared to the hoisting drums, the motor receiving its power from a motor generator set driven from the main power system. This set consists of an induction motor and a direct-current generator, with a fly-wheel swung between them, and a direct-current exciter overhung at one end of the set. The function of this latter machine is to excite the field of the generator and that of the direct-current hoist motor. The speed and direction of rotation of the latter machine is controlled by varying the field strength of the direct-current generator or by means of a rheostatic controller, which is conveniently located for the hoist operator.

In this set the induction motor is a three-phase 60-cycle, form M variable speed machine, while the direct-current generator is provided with commutating poles, and is designed for operating with a very weak field at all loads.

The fly-wheel is a steel casting, machined all over and perfectly balanced; it weighs about 12,000 lb. and operates at a peripheral speed of about 18,000 ft. per min.

In order to obtain this effect on the part of the fly-wheel of alternately storing and surrendering energy, the induction motor is arranged for variable speed operation; changes in speed being automatically controlled by the variation of the main line current, which is led through a small three-phase regulating motor operating a water rheostat in series with the secondary winding of the motor.

The torque which is produced by the full load value of the main line current in the windings of the regulating motor is exactly balanced by the weight of the moving parts of the water rheostat, so that there is no change in the resistance that is in series with the rotor winding of the motor generator set so long as the motor is taking full load current. If, however, it should demand more or less, there is an immediate movement of the water rheostat, tending to accelerate or retard the speed of the motor generator set to such a point that the induction motor once more takes full load, and the movement of the water rheostat is stopped.

The voltage of the exciter is maintained at a constant value during the speed variation of the motor generator set by means of a Tirrill Regulator.

Referring once more to Figs. 1 and 2, attention is called to the curve which shows the kilovolt-ampere input to the induction motor when a fly-wheel generator set is used. In these curves the undesirable starting peak has entirely disappeared; it was to secure this result that this equipment was designed.

This curve shows very clearly, indeed, how well the automatic devices perform the duty required of them, keeping the demand on the line practically constant, while the hoisting motor was called upon for several times its full load capacity.

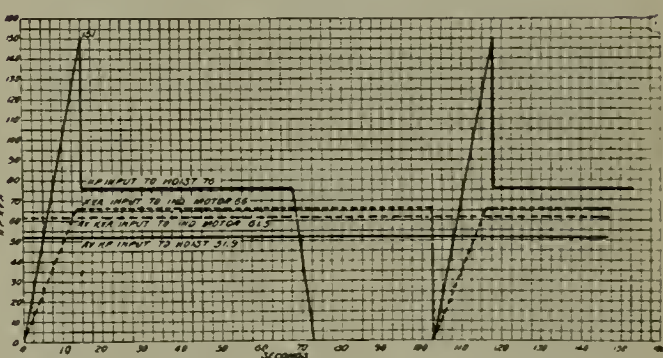
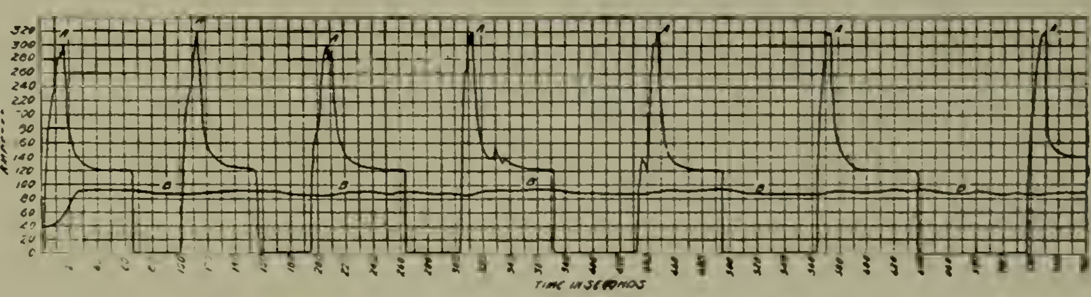


FIG. 2.—HORSE-POWER INPUT. BALANCED OPERATION.



CURVE A, CURRENT INPUT OF HOIST MOTOR; CURVE B, CURRENT INPUT OF INDUCTION MOTOR OF MOTOR-GENERATOR SET.

The Induction Motor as a Phase Converter

(General Electric Review, Nov., 1907, p. 221.)

If a motor having a polyphase primary winding be run single-phase, there will be induced in the idle windings electromotive forces which are dependent in phase upon the angular displacement of these windings from the primary phase; thus a three-phase motor, when run single-phase, gives three-phase electromotive force at its terminals; two-phase motor, two-phase electromotive force, etc.

The induction motor used in this manner presents an instance of double transformation in which energy is first transformed from one primary phase of the motor to the secondary or armature, and from these transformed into the other primary windings, which are known as tertiary windings.

Since the induction motor has comparatively poor regulation as a transformer, due to the unavoidable magnetic leakage in the air-gap, this double transformation can be accomplished at an appreciable loss of voltage and with distortion in the resulting polyphase system, depending on the self induction and resistance of the field and armature windings.

A calculation applied to a 600 h.p. 1150-volt quarter-phase motor shows with no load on the polyphase system a tertiary electromotive force of about 92 per cent. of the primary. With 200 amperes output, representing about 400 kw. input to the polyphase receiving circuit, the tertiary voltage has fallen to about 87 per cent. of the primary. With 200 amperes output at 70 per cent. power factor, the tertiary voltage falls to about 78 per cent. In the case of a 50-h.p. motor operating as a phase converter, with the polyphase system drawing about the rated power of the motor, the tertiary electromotive force would be about 80 per cent. of the primary electromotive force at unity power factor, and about 60 per cent. at 70 per cent. power factor.

The practical use of the induction phase converter is so necessarily limited on account of the voltage distortion that it is little more than an emergency machine.

Electric Drive in Cement Plants

(General Electric Review, Nov., 1907, p. 211.)

The cement mill must be kept in continuous operation. Most of the machines start under a heavy overload, and some are liable to short overloads during operation. The cement machinery does not require much attention and the driving machinery is not apt to get it. It is best to use induction motors owing to the dirty and dusty nature of the work. Results obtained from a great many cement plants indicate the horse power necessary to operate varies from 0.8 to 1.2 h.p. per barrel per day.

TABLE OF HORSE POWER, OUTPUT AND SPEED

Type	Size	H. P. to Drive	Revs. Per Min.		Output in Tons Per Hour				
			Pulley	Main Shaft	Hard Lime	Cmt. Rock	Marl Clay	Clinker	Coal
Gyratory Crusher*	5D	25–40	400–450	200	20–30	25–35			
Gyratory Crusher*	6D	30–60	400–450	200	30–40	30–50			
Ball Mill†	7	30–40	125	21–23	3–5	4–6		2½–3	
Ball Mill†	8	40–50	125	21–23	4–7	5–8		3½–5	
Tube Mill†	5′ x 22′	70–80	180	21–27	3–4	4–6	8–12	2½–3	2
Tube Mill†	5½ x 20′	80–90	180	21–27	4–6	5–8	10–15	3–4	2½
Kominuter†	No. 66	40–55	160–175		5–7	6–8		5½–7	
Griffin Mill‡	30″	25–28	190–200	190–200	1½–2½	2–3		2–3	1½–2
Griffin Mill‡	36″	30–35	135–150	135–150					
Griffin 3 Roll‡	30″	40	150	150	4–5	5–6			4–6
Fuller Lehigh Mill‡		30–50	210	210	3–3½	3½–4			2¼
Kent Mill‡		25–30	180–220	180–220	3–4	3½–4		3½–4	3–4

* Starts light when empty: overload torque at starting if hopper contains rock.

† 80 to 100 per cent. overload torque necessary for starting.

‡ Starts light.

Type	Length	H.P. to Drive	Revs. Per Min.	Output in Barrels Per Day
Rotary Kiln §	60 ft.	10–15	1–3	250
Rotary Kiln §	80 ft.	10–15	1–3	300
Rotary Kiln §	100 ft.	15–20	1–2	450
Rotary Kiln §	120 ft.	15–25	1–2	580
Rotary Kiln §	150 ft.	20–25	½–1	740
Rotary Kiln §	170 ft	20–30	½–1	800

§ Starts with 50 to 70 per cent. overload torque.

BOOK REVIEW

Long-Distance Electric Power Transmission

ROLLIN W. HUTCHINSON, JR.

The arrangement of the chapters of this book is in the order of the steps in transmitting power; namely, the laws of hydraulics, applied hydraulics, hydraulic machines and accessory apparatus, generators, switches and protective devices, laws governing transmission of energy, the transmission line, transformers, motors, converters, practical plants, and distinctive features of prominent long-distance transmissions.

The work is primarily intended as a book of reference for engineers and a text-book for students. Elementary mathematics is employed. D. Van Nostrand Company, 23 Murray and 27 Warren Street, New York City, are the publishers. The price is $3.00 net —345 pages.

Standard Polyphase Apparatus and Systems

MAURICE A. OUDIN, M.S.

This is the fifth edition of this work. A list of the chapter titles is given below as they indicate the ground covered. These chapters are entitled as follows: definitions of alternating-current terms, generators, induction motors, synchronous motors, transformers, rotary converters, motor generators, frequency changers and other converting apparatus, switchboard and station equipment, lightning protection and line construction, two-phase system, three-phase system, choice of frequency, relative weights of copper for various systems and calculation of transmission lines.

Quoting from the author's preface: "The excuse for this book is the demand for information, in a convenient form, on the characteristics and uses of the various types of polyphase apparatus, and on the actual working of the several polyphase systems now sanctioned by the best practice."

D. Van Nostrand Company, 23 Murray and 27 Warren Streets, New York City, are the publishers. The price is $3.00 net—369 pages.

CATALOGUE REVIEW

Stuart-Howland Co. send their illustrated catalogue of electrical supplies. This is a cloth-bound volume of 784 pages.

Fixtures for individual and for combinations of several Nernst lamps are listed by the Nernst Lamp Company in a recent catalogue.

Cranes and hoists are described in a four-page flyer by The Northern Engineering Works.

Those interested in lifting magnets will welcome a 32-page pamphlet just issued by the Cutler-Hammer Clutch Co., of Milwaukee, in which the subject is very fully treated. The booklet in question contains a number of full-page illustrations showing lifting magnets handling pig iron, steel stampings, castings, scrap and other material, together with diagrams, data on current consumption, information on lifting capacity of magnets, etc.

A booklet which should prove exceedingly useful to everyone who sells electric motors or motor-driven machinery to the Navy Department has also been recently issued by The Cutler-Hammer Mfg. Co., of Milwaukee, makers of electric controlling devices. This company for many years has made a special study of navy department requirements, and in the booklet just issued full descriptions, illustrations, dimension diagrams and shipping weights are given on starting panels, speed-regulating panels, machine-tool controllers, resistances, circuit-breaker panels, etc.

Bulletin No. 4533, issued by the General Electric Co., Schenectady, N. Y., describes and illustrates the several sizes of Wright demand indicators manufactured, together with capacities, prices, dimension diagrams, scales, etc.

In bulletin No. 4534 horizontal shaft type steam turbine sets up to 300-kw. capacity, both direct current and alternating current, are described.

Mercury arc rectifiers is the subject of bulletin No. 4530. It describes the simplicity and reliability of these devices for producing direct current for charging storage batteries and for many other commercial purposes.

Other bulletins are: No. 4532, motor-starting rheostats, and No. 4538, catenary line material.

Bulletins Nos. 8 and 9 describe the application of storage batteries to railway work, the latter giving an application to an alternating-current system. They are issued by the Gould Storage Battery Co.

The Fort Wayne Electric Works have recently published bulletin No. 1097, describing portable wattmeter calibrators, No. 1099 on enclosed direct-current multiple arc lamps, and No. 1101 on a multiple system of street arc lighting.

Rathburn vertical gas engines are described in a catalogue sent out by The S. M. Jones Company.

The October number of *Holophane* contains information of value to the illuminating engineer.

Single-phase self-starting alternating-current motors are listed with applications by the Century Electric Co. Motors of the horizontal, vertical and back-geared types are shown, with numerous applications. A cross-sectional drawing on pages 20 and 22 makes the ready ordering of spare parts possible.

The Allis-Chalmers Company send bulletins Nos. 1514 and 1515, descriptive of type J emergency valve for straight air-brake equipments, and type OB pneumatic governor respectively.

Catalogue D, issued by The Jeffrey Manufacturing Co., and illustrating coal and ashes handling machinery, is a valuable addition to the collection of all engineers engaged in power-station work.

Bank and office lighting by electricity is the title of a late publication issued by the Nernst Lamp Company.

Bulletins Nos. 106 and 107, published by The Electric Storage Battery Co., give information on the subject of application of storage batteries to railway work.

Graphite for October contains numerous items of general interest. A letter from Prof. Plumb, of Purdue University, speaks well for the operation of Dixon's graphite brushes, made by Joseph Dixon Crucible Co.

The October number of *The Emerson Monthly* gives considerable data on the application of small power motors to various machines.

Personal

At the University of Wisconsin, the chair of electrical engineering, recently made vacant by the resignation of Professor Dugald C. Jackson, who is now in charge of the department of electrical engineering at the Massachusetts Institute of Technology, has been filled by the appointment of Mr. Orville H. Ensign. Professor Ensign is recognized as a pioneer in the electrical profession, having been identified with undertakings of great magnitude and importance for the past 20 years.

The Allis-Chalmers Company has opened an office at Deadwood, S. D., with Mr. O. F. Purnell as district manager. Special attention will be given by Mr. Purnell and the members of his staff to the sale of mining, crushing, pumping, power and electrical machinery, many installations of which have been made by Allis-Chalmers Company and its predecessors throughout that section of country.

Mr. Edward E. Scribner has recently joined the sales force of the Holophane Company. His work will be among architects whose interest in the Holophane system of illumination has grown to such proportions as to warrant the company in detailing a special representative to serve them. Mr. Scribner's headquarters will be New York City.

Mr. Walter B. Snow announces that he is prepared to undertake work of any kind in the broad field of publicity for manufacturers of machinery and allied products. His regular service will cover the conduct, on a salary basis, of the publicity departments of a limited number of non-competitive clients. Special service will be rendered to others in the form of general advertising, catalogue making, technical writing and investigation. The intimate acquaintance with engineering in general, and publicity in particular, acquired during nearly 25 years connection with the B. F. Sturtevant Co., encourages him in the belief that this service can be made of exceptional value.

Announcement is made of the resignation of David B. Carse from the chairmanship of the advisory committee of the U. S. Steel Corporation. Mr. Carse and his brother, John B. Carse, have composed this committee since its formation five years ago; the duties of the committee being to keep track of all expenditures of the corporation under the appropriations by the finance committee. Mr. John B. Carse still remains with the corporation, and will take care of the future work of the committee. In leaving the steel corporation, Mr. Carse does so with the idea of taking up again the business of Carse Brothers Company, which deals largely in machinery and supplies for railroad work. This company has been reorganized and its headquarters removed from Chicago to New York, with offices at 12 Broadway.

Mr. H. Hobart Porter, of Sanderson and Porter, engineers, has been appointed chief engineer of the Interborough Metropolitan Co.

J. G. White & Company have contracted with the Alliance Gas & Power Co., of Alliance, O., to act as consulting engineers and supervise the purchase and installation of new machinery, consisting of a large turbine generator and a battery of 350 h.p. boilers with complete auxiliaries for both electrical and steam ends. The new equipment will be installed in the old plant of the Alliance Gas & Power Company through the winter and will be transferred later to a new plant, the construction of which will be begun by the engineers early in the spring.

Mr. Richard T. Laffin, vice-president and general manager of the Manila Electric Railroad & Light Company, has resigned, having completed the task of establishing the operating organization of this property on a sound earning basis. The management is now assumed by Mr. C. B. Graves, who has been Mr. Laffin's right-hand man since the property was placed in operation, three years ago, officiating as manager of the lighting and power department. Mr. Laffin is still interested financially in the Manila properties, and resigns to take the management of another group of public utility properties in which J. G. White & Company, Inc., are largely interested.

Trade News

The American Railways Company, through A. S. Kibbe, engineer, have awarded the contract for the foundations of the power-house of the Home Electric Light & Power Co., at Tyrone, Pa., to the Raymond Concrete Pile Company, of Chicago and New York.

A type of switching locomotive has been built by The Jeffrey Manufacturing Company, of Columbus, O., for use in handling freight cars for the Cerveceria Cuauhtenoc Brewery, of Monterey, Mexico. This style locomotive takes the same electrical equipment as the mine type, the only changes being in the side and end frames and the addition of a platform and suitable cab to accommodate the conditions incident to surface work. The motors are of the water-proof steel frame type having drum wound armatures, laminated pole pieces, oil lubrication with auxiliary grease boxes and liberal wearing surfaces.

These locomotives are built in sizes from 10 to 30 tons with two motors, and in larger sizes with three and four motors, arranged with rigid frame or with double trucks having flexible wheel base, depending entirely on the condition.

Among the exhibits at the Atlantic City convention of the American Street & Interurban Railway Association, was that of the Golschmidt Thermit Company, of No. 90 West Street, New York. It was shown that by its new system of using yellow wax as a pattern or matrix for the mold, it was possible to repair motor cases at a cost seldom exceeding $15.00, and often for $4.00 or $5.00, thus enabling the saving, at a small expense, of motor shells, which would cost from $80.00 to $100.00 to replace.

The New York, New Haven & Hartford Railroad is now running its 35 Westinghouse electric locomotives with local trains between the Grand Central Station, New York, and Stamford. The success of the operations involved has exceeded the expectations of the officials of the railway company and of the manufacturers, and it is understood that a considerable addition to the locomotive equipment is under negotiation. The New Haven Company, it is authoritatively stated, has paid the manufacturers practically in full for the entire work done to date and continues to pay as the work makes progress. Each locomotive was intended to haul only five-car local trains, but it frequently happens that trains of as many as eight cars are handled with ease by a single unit, and on a recent occasion one of these locomotives pulled a broken-down steam locomotive with its train into Stamford so that a new engine could be attached.

The new foundry of R. Hoe & Co., printing press manufacturers, of New York, has been equipped with three 10-ton electric traveling Northern Cranes, each of about 56-ft. span; and also with a No. 72 Newten Cupola, all furnished by the Northern Engineering Works, Detroit, Mich.

The Northern Engineering Works have also furnished for the Bingham Junction plant, United States Smelting Co., Utah, two 12-ton overhead traveling cranes.

Some months ago the Cutler-Hammer Mfg. Co. announced their purchase of The Wirt Electric Co., of Philadelphia. They now beg to advise that they have consolidated the Wirt business with that of their New York plant at Park Avenue and 130th Street, where the manufacture of Wirt apparatus will be continued.

The Tremont & Suffolk Mills, of Lowell, Mass., will add to the present power equipment, recently purchased, a 1500-kw. Allis-Chalmers turbine direct coupled to a 2000-kw. generator wound for 60-cycle, 3-phase circuits to operate at a speed of 1800 rev. per min.

The new equipment includes, in addition to the main unit, two exciter units, one motor and the other engine driven 50 kw.

The Oliver Typewriter Company has recently purchased new power and electrical units for the plant at Woodstock, Ill., comprising a 22-in. by 42-in. Allis-Chalmers horizontal heavy duty Corliss engine direct-connected to a 300-kw., 240-volt, direct-current generator of the same build for carrying the power and lighting load.

Among the large industrial corporations of the country which the recent financial crisis did not affect adversely, Allis-Chalmers Company, of Milwaukee, is especially prominent, for the reason that its name has previously been coupled with various rumors circulated largely for speculative effect. It stands unshaken, despite the tremendous load of orders being executed in its shops and the necessity for large current funds.

The first session of the annual meeting of the managers of the General Electric Company was held at the main office of the company in Schenectady, Oct. 28, 1907.

Owing to the national interest taken in the business affairs of the industrial world, the principal topic was a discussion of the general situation in the electrical field.

The satisfactory condition of the company's business was indicated by a statement that orders received during the current year to date exceeded those of the corresponding period of last year by fully 15 per cent. The volume of orders and prospective demand for supplies and for the various lines of smaller electrical devices which the company manufacture is very satisfactory.

There has appeared in the technical and popular press an item to the effect that the General Electric Company obtained an injunction against the City of Nashville preventing the use of certain electric generators manufactured by the Bullock Electric Manufacturing Company. It appears that a motion for preliminary injunction was filed by the General Electric Company against the City of Nashville alleging infringement of the Parcelle patent. This patent, which has but a few months more to run, covers very specifically a mechanical device for fastening the laminated pole-pieces of a dynamo-electric machine in position on the frame. This construction was employed in a few machines manufactured several years ago by the Bullock Electric Manufacturing Company, before its affiliation with Allis-Chalmers Company; but has since been abandoned for a better device. The City of Nashville was given 60 days from the date of the Court's order within which to make the necessary changes to avoid infringment. The simple changes required were readily made by Allis-Chalmers Co., within the time specified, in such a manner that the operation of the plant was not interfered with.

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Tests of Service Meters

THE Public Service Commission of the Second District of New York State has completed preparations for testing service meters now installed.

The cost is slight in any case. Although the applicant deposits a fee with his request, the fee is returned to him when the meter is found over four per cent. fast. Fees range from one dollar for the five-ampere size to three dollars for those of 25-amperes capacity.

This will be welcome news to the electric operating companies, as it partially relieves them of the task of making tests. Consumers who object to an increase in amount of bills cannot now require the company to devote the time of meter experts to useless work. The only tests necessary are those for the adjustment of these instruments.

The natural tendency of wattmeters is to run slow. As dirt accumulates and the bearings become worn, the friction increases, thus producing a lower record than actual. Therefore, the average of all adjustments made after continued service is to increase the speed. This fact is the cause of some dissatisfaction, since after a customer asks for an inspection of the meter, the bills are usually larger than before.

Connections of High-Tension Apparatus Inside of Power Stations

The advisibility of providing a certain amount of insulation for wires connecting high-tension apparatus is well worth consideration in all power-station equipment. Thoroughly safe insulation maybe prohibitive in cost for some stations, but a measure of insulation is cheaply provided. It has its advantages. Such protection will prevent mere brushing against the wires from developing into shorts, thus lessening the number of fatalities and diminishing the number of short circuits.

Usually, an insulation which is not designed for full working voltages is considered worse than bare wire. This stand has its foundation on the fact that station attendants who see insulation in place will rely on its efficiency, while if it is not there they take proper precautions before working in the proximity of the wires.

When we speak of a dielectric covering for a given voltage, we understand one that will withstand twice normal working voltage while the wire is submerged in water. Is an engineer justified in stating that an insulation which will not withstand this test is worse than none? It depends on the purpose for which the insulation is to be used.

The air in an electric station is dry. Therefore, a dielectric that is efficient when dry certainly has a value on wires inside of a station when moisture is not present. Also, its thickness need not necessarily be sufficient to withstand a voltage twice normal in order that it afford some protection.

A thick covering of a low-grade rubber compound or even many braids saturated with asphalt over wires will prevent dangerous shocks to persons coming into contact with them momentarily. Moreover, such a protection will prevent a number of short circuits that would otherwise occur.

On the other hand, the average station attendant considers wire that is insulated safe to handle, and we must not neglect the human element of these men when designing an equipment. The station attendant finds the equipment safe in dry weather, and naturally neglects to consider its condition after periods of shut-down, when moisture has condensed on the apparatus.

In general, where the station is operated night and day and the building provides protection from the weather an insulation of a low cost is better than none, provided the wires are erected on high-voltage insulators. Where the station is shut down at times and the operators cannot otherwise be depended upon to treat wires as they would bare wires, the insulation had best be omitted entirely.

Barriers vs. Clearances

The high cost for barriers between conductors is sometimes considered excessive, large clearances being proposed to eliminate the necessity for them.

Barriers between the poles of circuit breakers permit of reducing the width of switchboard panels to a size below that required without their use, thus effecting a reduction not only in the cost of the switchboard panels alone, but also in the length and cost of bus bars and connections.. Frequently the size of the building required to contain the switchboard may be diminished.

Power stations are costly, and where the omission of barriers enlarges their size such an omission cannot be considered. This is the case with nearly all central stations with a number of high voltage feeders emanating therefrom. Such stations have usually an elaborate system of marble, soapstone, brick or concrete compartments for containing high potential circuit breakers, other apparatus, bus bars and connections.

Central stations supplying a few sets of feeders and containing only one or two generating units; also substations fed by but one or two feeders and containing a small number of transformers do not require a large proportion of the total space for high voltage connections and the necessity for barriers is not apparent without calculation of the relative cost of barriers and space. These stations have a floor area for the apparatus, and the space above the apparatus is ample for running high voltage connection wires at distances sufficient for the voltage.

Though large oil-type circuit breakers usually warrant their erection in separate compartments when placed on the floor as the heavy oil-type circuit breakers require, breakers of the air-type when mounted at a distance from the floor may often be mounted without barriers between poles of opposite polarity without encroaching on the available space in the building.

High potential devices and connections may often be economically installed in the space above machinery in stations with few high-tension connections to the outside lines, while the numerous feeders distributed from central stations and the many connections to apparatus therein require the utilization of floor space with a consequent increase of building for which reason the reduction in cost of building more than compensates for the cost of the barriers.

Brick and Concrete for Switchboard Compartments

Both brick and concrete structures make efficient compartments for switchboard apparatus. The function of these structures is to isolate each device from others so that a breakdown at any one point will only affect the line connected at that point. The brick or concrete prevents the spreading of trouble, and is not for the purpose of insulation.

Brick is available in nearly all locations, and labor for properly building the walls in accordance with plans will generally be found without difficulty. Insulators for holding studs are mounted on heavy slate or soapstone bases and built in with the brickwork. Slabs of the cheaper grades of marble or of soapstone or slate make suitable floors and tops to the compartments. The structure thus formed resists intense heat and prevents communication of fires.

Concrete requires the use of good sharp stone, clean sand and dry cement. This material is found to a somewhat limited extent and requires care in preserving the cement from the weather.

For large work consisting of many compartments, most of which are alike in size and shape, a few sets of wooden molds suffice for concrete building. The timbers and planks used for forming are moved from one portion of the job to the next as the concrete hardens, thus minimizing the material and time required by the carpenters. The cost for a given volume of large dimensions is less for concrete than for brick owing to the better utilization of labor and material. For stations having a small switchboard equipment and requiring no other concrete work, brick will be found cheapest for switchboard compartments. In stations having a large switchboard equipment, and especially those built partially of concrete, it will be found most economical to have the switchboard structure likewise of concrete.

Automatic Circuit Breakers with Generators

Automatic circuit breakers between alternating-current generators and bus bars are now generally omitted entirely, or where they have been installed the tripping device will be found locked in most of the stations. The reason for this is due to the heavy cross currents between machines when connecting in parallel and whenever there is any tendency to hunt. At such times the machines are improperly and unnecessarily disconnected with the result of necessitating resynchronizing and perhaps doing damage to the generators which remain connected to the board after one or more have been automatically disconnected from the bus bars. The omission of automatic trip coils reduces the troubles of the switchboard operator and prevents the liability of the total load being thrown on one or two generators which may already be carrying full-rated capacity.

When the automatic features are omitted, dependence is placed on the switchboard operator to disconnect the load when it has assumed proportions dangerous to the operating equipment. Electrical apparatus will carry current somewhat in excess of normal rating for short periods and no immediate bad effects result from forcing for a reasonable length of time for those in charge to see the danger and remove the cause.

Operating companies can better afford to have part of their equipment damaged than to incur the loss of trade resulting from dissatisfaction with a service that is unreliable. It is better for them to take the chances of burn-outs than to have the supply disconnected at critical times.

There is, however, a class of stations which supply light and power for purposes where a momentary interruption to the service is not of such great importance as to justify the acceptance of risks with overloads, though the switchboard attendant can be relied upon to act quickly in emergencies. This class is considered below with respect to the voltage regulation of the alternators.

Alternating-current generators as made ten to fifteen years ago had a voltage regulation of from eight to twelve per cent. The current with armature terminals short-circuited and normal full-load excitation is from three to four times full-load current. Such machines may be operated for a few minutes on a dead short circuit without injury to the insulation. They therefore do not require automatic protection, since a sufficient time may elapse for the manual operation of switches before disastrous results follow.

At the present time a generator regulation is specified to care for low power-factor loads with a drop in potential of five to eight per cent. from no-load voltage. The short-circuit current ranges from five to seven times full-load rating. The copper loss and the heating of conductors increases as the square of the current, five times normal current giving twenty-five times normal full-load heating. This rise in rate of heating is so rapid that windings are endangered. Also, the shock of such a heavy draft of power as is incurred by short circuits on generators of close regulation may buckle the connecting rods of engines or injure the motive power in other ways. Both the heating of the windings and the mechanical strain result almost simultaneously with the overload and give no opportunity for manipulating switchboard appliances.

Overloads and short circuits nearly always occur on some feeder and are disconnected automatically at the feeder. However, the feeder breakers cannot be made of a size to open the full capacity of the station without a very large outlay for these devices. For instance, take the case of a 100-ampere feeder on a system of 50,000 kw. A short circuit on the feeder causes a great deal more than 50,000 kw. to flow to the point of trouble, and provided the feeder breaker does not open instantaneously arcs will be maintained at its contacts to the destruction of a portion of the equipment. There must be some current interrupting device between the generators and the feeders that is capable of disrupting the short-circuit current of the generator.

One good plan is to provide a large circuit breaker on a total load panel of a size capable of handling the full station output. Any overload that may cause a breakdown in the feeder-controlling devices will then be opened at the total load panel. Automatic protection at this point does not interfere with the station operation. The cost for this addition to the total load panel is, however, no inconsiderable item, and while the features are advantageous the increase in expense is appreciable.

The next best plan is to supply automatic overload trip coils on the generator leads and to set the point of release at three to four times full-load current. This high setting prevents trouble from small overloads and from cross currents of moderate amount. In addition, the motive power is protected from mechanical injury and overloads beyond the capacity of feeder breakers are opened at the generator panels.

Series transformers for operating the trip coils or the relays employed with them should always be placed as close to the generator as possible. Leakage current from leads between the machines and the switchboard operates through transformers thus connected, which would not be the case if they were at the switchboard.

Disconnecting Switches on 2300-Volt Circuit-Breakers

The average electrical worker handles live wires at 2300 volts with little more care than in making alterations and repairs to low-potential systems. Why not provide means to eliminate the possibility of shock from this voltage?

Disconnecting switches between the bus bars and circuit breakers are rarely provided on voltages as low as 2300 volts. Oil tanks are removed and refilled with one set of live contacts, and repairs are made to the mechanical links, levers and catches while the leads are connected to the bus bars.

Moderately high potentials, that is potentials up to 3500 volts, are insulated without difficulty. Shocks from contact with voltages up to this amount are only fatal when thorough contact is made with the live parts. Nevertheless, when an attendant is working with tools he may receive a dangerous shock from the tools touching live wires at a voltage as low as 600 volts, and proper precautions should be taken to protect him as far as possible.

With the present state of switchboard construction the back of the board is crowded with connections, small space being available for mounting any additional switches. There is no good reason why panels should not be made large enough to accommodate any additional apparatus which may be deemed necessary. Disconnecting switches can be placed back of the board on their own bases or mounted directly on the panel by making the switchboard of sufficient size.

Very few of the standard panels as now erected permit of adding switches in the circuit-breaker leads, not only on account of space not being available for the switches, but also because of lack of room in which to bend the leads from the bus bars. The addition of switches to present switchboards is not often possible without an undesirable complication of wiring.

Oil switches of the remote control type may be classed in this respect with high-voltage stations, since additions to their leads are effected without difficulty.

Where conditions permit their use, the additional cost of apparatus and space for disconnecting switches is so slight that they may safely be recommended for moderately high-potential circuit breakers.

Switches for Transformers which Supply Rotary Converters

Rotary converters are of two general classes, namely, compound wound and shunt wound. Usually, reactances are connected between the compound converters and the transformers, thus producing an inductive load to be opened by the transformer switches.

It is a well-known fact that loads of low-power factor arc severely at switch contacts when the circuit is broken. Unless the separation of these contacts is large, the arc will hold, expel the oil and perhaps cause serious trouble. Circuit-breaking apparatus which gives satisfactory service with shunt-wound machines cannot be expected to give equally as good results when the winding is compound on account of the poor power factor of the accompanying reactances.

There is a lagging current due to the reactance and a leading current in the converter which, though they may produce unit power factor at the transformer terminals, are liable to produce a momentary rise of voltage that will be apparent at the switch on the primary side of the transformers.

The power factor measured at the slip rings of the rotary converter depends on the amount of excitation for any given load. The current leads the voltage with over excitation and lags behind it when the field current is less than normal. Consequently, shunt machines have a poor power factor at times of improper excitation.

Usually, the direct-current side is opened first, but with automatic overload protection on the alternating-current side there can be no certainty that such will be the case. Switches on the primary side of the transformers must be capable of handling the load under any conditions of loading and over or under excitation. It is good practice to set automatic tripping coils at a much larger percentage of overload on the alternating than on the direct-current side of these machines.

Another point to be considered is the maximum volt-ampere capacity to be opened. Switches and circuit breakers have two ratings: one is the current they will carry without undue heating and the other is the kilovolt-amperes they will break at zero power factor. It is not sufficient to require a 20,000-volt, 50-ampere switch for the transformers of a 1500-kw. rotary converter supplied by a 20,000-volt line, it must also be capable of breaking the maximum short circuit to which the apparatus will be subjected. The circuit breakers or switches at the central-power stations can be relied on to disconnect the feeder when short circuits do occur, but it is highly desirable that the feeder remain in service. Each bank of transformers with its connected rotary converter will deliver a definite load in kilovolt-amperes with the positive and negative direct-current leads connected together. This load should be calculated and the capacity of the switch or breaker supplying the unit made of a size to break this load at zero power factor.

Another requirement is the maximum capacity which can be fed back to the primary feeder in case a ground occurs in it while the direct-current bus bars remain alive from other sources of supply. The required capacity will be found by calculating the ohmic and inductive drop in potential through the unit with full direct electromotive force. Straight overload circuit breakers as usually mounted on the direct-current panels will ordinarily open a reverse current above their overload adjustment, but after the one in the leads of any particular unit is opened, the converter runs from its momentum and generator power through the transformers for a sufficient time to maintain an arc of dangerous proportions.

Circuit breakers or switches on the high-tension side of transformers supplying rotary converters should be of a size to handle the greatest load that can be forced through the unit from either direction.

Leads Between Generators and Switchboards

Where single-conductor and lead-covered leads between generators and switchboards have been installed, the lead sheath has been fused in one or two instances. In other cases the static voltage is excessive with leads of this nature.

The explanation is simple. The sheath acts in a manner similar to the secondary of a series transformer. Current is induced in it to cause excessive heating, the amount of current depending on the resistance of the sheath, on the resistance of contacts between the sheaths, on the relative distances between the conductor and sheath and the other cables and on the current in the conductor. Under extreme conditions, that is, where the two ends of the lead covering over each of a pair of cables are securely connected by bonding, full-load current in the cables produces heat sufficient to melt the lead.

Where generator leads have been installed, as here described, the defects can be remedied by taping the sheaths at points in contact with metal. If they are in separate tile ducts, the resistance of the tile is sufficient. If two or more cables are in one duct, each can be covered with canvas hose or other slight insulation. The difference in potential at the ends of the cables is less than 10 volts, so that almost any form of insulation suffices. Excessive current is only found where the connections between the sheaths have a resistance less than one ohm.

Static troubles arise from the capacity of the cables. If the voltage between lead sheaths be measured with a voltmeter that does not take power for operation, such as an electrostatic voltmeter or a spark gap, it will be found equal to the difference of potential measured between conductors. In the short distance from the generator to the switchboard the cables have such a small electrostatic capacity that the power is small. Slight sparks carry the current, the power is not sufficient to maintain an arc. These sparks are severe at times of switching, when the abrupt breaking of the circuit causes the voltage to increase to a value much higher than normal.

It is a usual occurrence for switchboard operators to receive a shock from static when throwing switches on lines of as low as 1000 volts. The spark jumps an air-space of four to six inches, showing the voltage to be very high. The shock is not fatal for the same reason that the shock from an electrostatic machine is not fatal, the power is too small to produce more than a momentary current.

The best method of preventing these sparks is to connect the lead sheaths with a copper wire. This connection permits the charging current to flow between the cables. The charging current in the short lengths inside the station is of such a small amount that there is no appreciable loss from this source. The connection must only be made at one point on each cable unless a resistance of over two or three ohms is inserted, as the induced current will then have a complete circuit through the sheaths.

Multiple conductor cables give best results with alternating current and should be installed when possible.

Three Ammeters on Three-Phase Generator Panels

Nearly every engineer has been confronted with the question of the advisability of placing three ammeters on generator panels. At the present time, switchboards are so standardized that he will find a panel exactly suited to the requirement among the numerous lists of the manufacturers so that the decision depends on the relative costs of a panel with three ammeters and one with a single ammeter only.

Panels with a single ammeter are generally provided with plugs giving readings on any of the phases. Three ammeters give continuous readings on all of the phases. The single ammeter with plugs gives readings only at the discretion of the switchboard operator.

How important the question of cost is cannot be reduced to a comparison with operating necessities in all stations. The necessity for three ammeters giving continuous reading on all the phases of a generator can hardly be overstated.

Consider two generators supplying a load in multiple and suppose one generator lead becomes disconnected or one phase of its winding suddenly develops an open circuit. All of the load on that phase must be supplied by the second machine with consequent heating and ultimate breakdown. The three ammeters would show a defect immediately. The single ammeter might and might not show the trouble.

A highly desirable addition to all stations is a total load panel with three ammeters even when the generator panels are thus supplied. The load panel then tells when the phases are balanced on the bus bars at the load while the machine panels show the condition of the generating equipment.

As the safe operation of electrical machinery is determined by the current, measurement of the current cannot be made too carefully or too frequently, and any expense incurred by instruments for this purpose is wisely made.

The Starting of Rotary Converters

Data Regarding New York Stations

THE following data regarding substations of electric systems in and near New York is here given because of the great interest created by the publication of an article on this subject in the November issue.

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD COMPANY.

INITIAL ELECTRIC TRACTION SYSTEM. SUBSTATIONS.

(1) Number of substations—three.

(2) Total number of rotary converters—nine.

(3) Capacity of rotary converters—six 1500-kw. and three 1000-kw.

(4) Method of starting—rotary converters are usually started as direct-current motors connected to the direct-current bus bars. Provision is also made for starting the rotary converters from the alternating-current end, ½ and ¾ voltage taps being provided on the secondary windings of the transformers.

(5) Approximate number of starts—2000.

(6) The rotary converters have dampers on the pole pieces.

(7) These dampers are known as low resistance type.

(8) There is not the tendency to hunt with turbines for prime movers that there is with reciprocating engines. There has been no trouble in the above substations from hunting.

(9) The field coils are divided to prevent abnormal rise of voltage at the time of starting.

(10) The alternating current side of the rotary converter is not permanently connected to the transformer secondaries.

(11) For direct current starting the field circuit is provided with a radial switch arranged so that the rotary may be self or separately excited. Separate excitation from the direct-current bus is used only for starting the rotary from the direct-current end. Knife switches are installed in the circuit between the secondary of the transformers and the slip rings of the rotary converter. The rotaries are synchronized by closing an oil switch on the high-tension side of the transformers.

Philip Torchio, chief electrical engineer, New York Edison Company, gives data regarding the substations of this company.

THE NEW YORK EDISON COMPANY. SUBSTATIONS.

(1) Number of substations—23.

(2) Total number of rotary converters—107.

(3) Capacity of rotary converters—19 2000-kw., 64 1000-kw., 24 500-kw. units.

(4) Method of starting—started from direct-current end under normal conditions. For emergency operators are trained once a week to start converters from engine unit, bringing them up from rest to full speed.

(5) Approximate number of starts—normal method of starting about an average of one operation a day for each rotary, since beginning of operation in 1898. Emergency starting from engine one training a week since 1903.

(6) About 50 per cent. have dampers.

(7) These dampers are known as low resistance type.

(8) The dampers reduce about ¾ the fluctuation under similar provocation, than rotaries without dampers.

(9) The field coils are divided to prevent abnormal rise of voltage at the time of starting.

(10) The alternating-current side of the rotary converter is permanently connected to the transformer secondaries.

(11) Iron grid resistances are used for starting.

J. R. C. Armstrong, chief electrical engineer of the New York City Railway, states as follows:

"Our method of starting rotary converters from the direct-current bus bars is simple and rapid. Moreover, the cost for starting apparatus is reduced to a minimum.

"The machines are started as direct-current motors, a resistance being connected in series with the armature and gradually cut out as the speed of rotation increases; about as shown in Fig. 1.

"One starting resistance is provided for each substation. This is connected to the direct-current bus bars through a starting circuit breaker which is set to trip at 600 amperes for 1000-kw. rotary converters. The starting circuit breaker is provided with a shunt trip coil in addition to the regular overload trip coil, thus permitting of operation by means of an auxiliary circuit, as described below.

"The starting resistance is connected to a number of single-pole double-throw switches equal to the number of rotary converters in the substation as shown in Fig. 1. Normally, all switch blades are thrown into the upper contacts. Connection for starting any machine is made by throwing its switch blade down into the lower contacts. In the diagram this connection is completed for machine No. 2.

"After this connection of the rotary converter through its double-throw switch to the starting resistance and starting circuit breaker is completed, the four-point starting switch is closed to the first starting notch, at which point all of the starting resistance is in circuit. The starting switch is next closed to the successive notches, thus short-circuiting the starting resistance in steps. A resistance of one-half ohm is left in circuit for the purpose of neutralizing the effect of voltage variation on the speed of the machine. With this resistance in circuit no difficulty is encountered from unsteady rotary converter speed with a fluctuating direct electromotive force. Exact speed regulation is obtained by adjusting the rotary converter field rheostat.

"When approximately synchronous speed has been attained, the four-pole field switch is opened to the position as shown making contact at B. This opens the field circuit and discharges the field energy through the discharge resistances.

"It is to be noted that the field circuit in this case is divided into four sections, and that the field switch is of standard design with discharge clips. The division of the field into four sections not only reduces the arc at breaking this circuit, but also reduces the voltage induced in the field

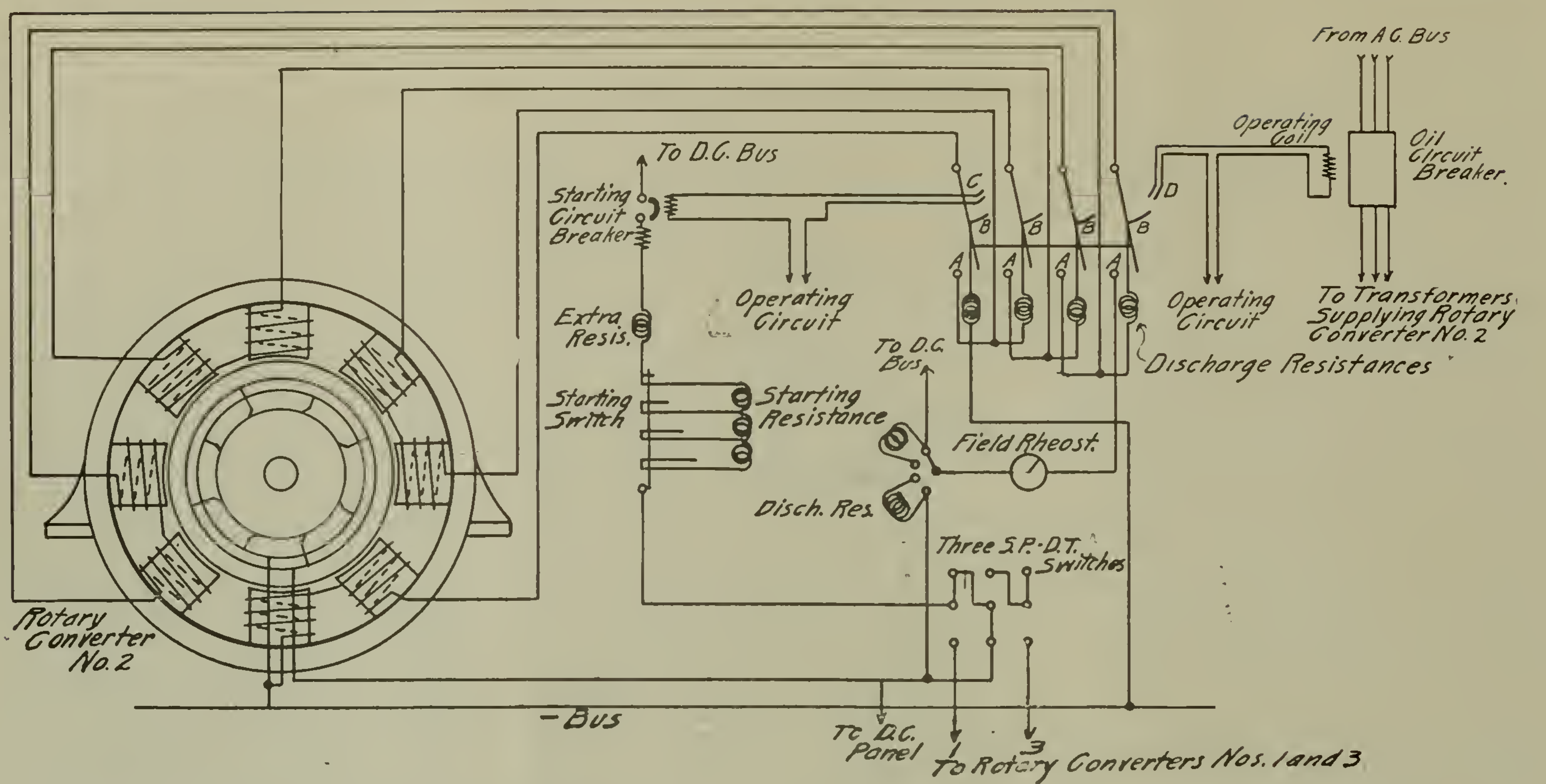


FIG. I.—DIAGRAM OF CONNECTIONS SHOWING METHOD OF STARTING ROTARY CONVERTERS—NEW YORK CITY RAILWAY.

to one-quarter of what it would otherwise be when connection is made to the alternating-current bus bars. Two sets of contacts in addition to the discharge clips are supplied at C and D.

"The four-pole field switch as it is opened completes contacts at C. This completes the auxiliary circuit through the shunt trip coil of the starting circuit breaker, trips it and opens the armature connection to the direct-current bus bars.

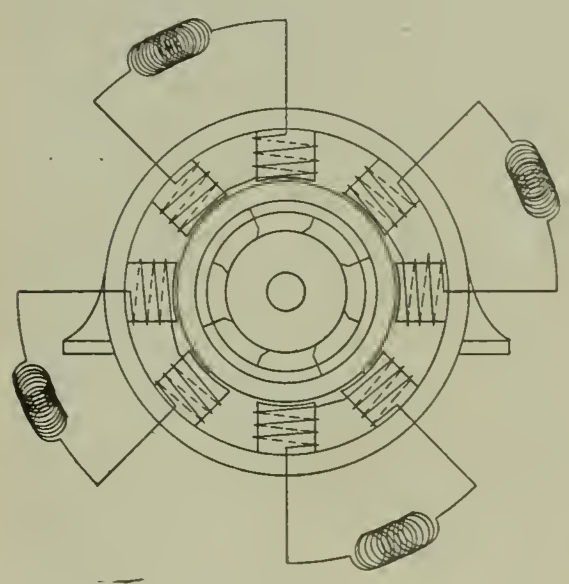


FIG. 2.

"As this switch is opened after making contact at C, contact is made at D which closes the oil circuit breaker and connects the rotary converter to the alternating-current supply. The field switch is then closed to contacts A thus closing the field circuit.

"The operation of starting is then complete. The starting circuit breaker remains open, the rotary converter is operated from the alternating-current bus bars, is self excited, and may be connected to the direct-current bus bars at the switchboard.

"We have never had the polarity to reverse with this method of starting.

"The method is a combination of the methods of starting from the direct-current bus bars and from the alternating-current bus bars. The rotary converter is brought up to speed from the direct-current side, floats for an instant and then is operated from the alternating-current side.

"The four-pole field switch is opened and closed. The difference in the time element of operation between the air-break circuit breaker on the direct-current side and the oil circuit breaker on the alternating-current side is sufficient to insure the machine being disconnected from the direct-current supply before connection is made to the alternating current.

"The many sections of the field winding prevents abnormal rise of voltage while the field switch is being opened and closed.

"Of course, one can imagine that times may occur when direct current would not be available for starting. If there is any probability of the direct-current supply failing, one or more rotary converters should have provision for starting as induction motors. In this case the field switch should be double-throw to reverse the polarity as desired.

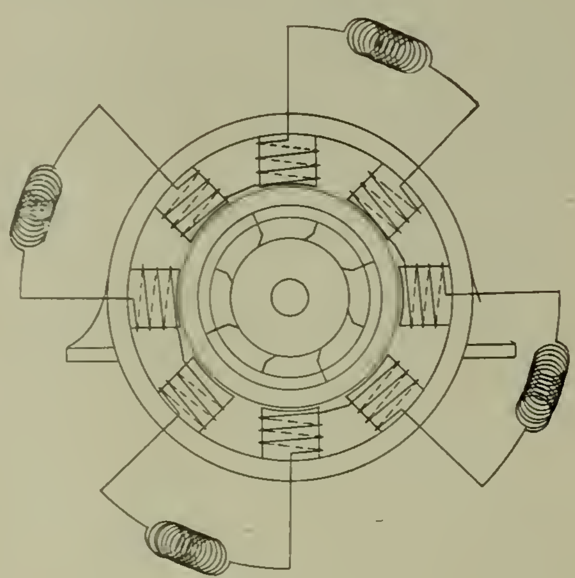


FIG. 3.

"Under normal operating conditions we start a rotary converter from rest and connect it to the load within one minute.

"There are two methods of connecting the resistance to the field of the rotary converter. That shown in Fig. 1 is represented diagrammatically by Fig. 2. The other method is as per Fig. 3. Here it will be seen that the resistance in Fig. 3 gradually cuts down the current in the field as the switch is opened, while in Fig. 2 the resistance is a discharge resistance absorbing the energy from the field."

The Electric Illumination and Wiring of the New York Public Library

CHARLES JENKINS SPENCER

WHAT is perhaps the most important system of illumination and wiring now being installed is that of the New York Public Library, Fifth Avenue, 40th to 42d Streets. The illumination of this building is arranged to the best advantage for the benefit of the readers. Owing to the handsome and imposing nature of the structure, its lighting fixtures must be so designed and so placed as to harmonize with an architectural effect rarely equaled. About 25,000 incandescent lamps and numerous motors are required.

NEW YORK PUBLIC LIBRARY AS SEEN FROM FORTIETH STREET AND FIFTH AVENUE.

The scope of the work now being installed includes wiring and apparatus for light, heat and power, wiring for watchman's clock, time clocks, call bells, complete closing gongs, fire alarm, automatic fire alarms, wiring for messenger calls, public telephones and complete intercommunicating telephones.

An electric power station will be placed in the building at some future date. This article includes only that portion of the electric equipment which is erected during the construction of the building and which has been determined in detail. The construction is described as found in place. Future work is described as far as is possible at the present time. Paragraphs are taken from the specifications for the benefit of those engaged in similar work.

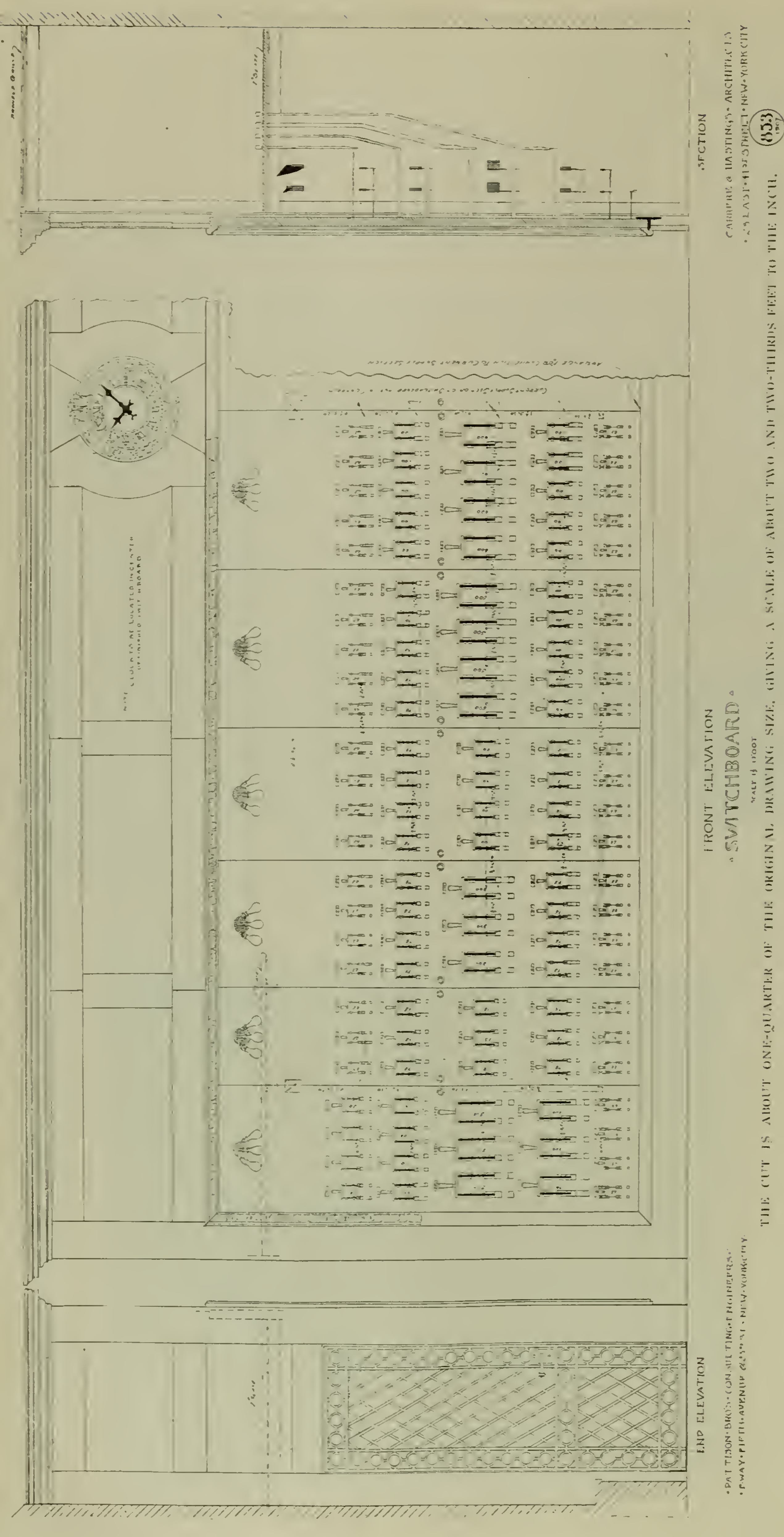
The feeders are distributed from one main switchboard. This switchboard consists of white marble slabs two inches thick, supported on an angle-iron frame braced with angle iron imbedded in the wall. A single angle iron runs across the entire bottom of the slabs. No weight of the slabs is carried by the bolts fastening them to the frame.

The front of the slabs is polished. The joints between slabs are made plain with a bevel on each edge. The space above is enclosed by electro-bronze screen work. Ends are enclosed by white marble slabs one inch thick, and have at each end an iron grill door plated in electro-bronze finish. White marble is placed immediately behind the molding below the switchboard. Ends of bolts holding the slabs are covered with acorn-shaped coppered brass cap nuts. The front of the board is surrounded by a bronze-plated iron molding three inches wide, polished and lacquered. This metal is not less than $^3/_{32}$ in. thick at any point.

All circuits and switches are marked with engraved copper plates $^3/_{32}$ in. thick with beveled edges and filled black enameled letters.

Connections do not show on the front of the board, and all work at the back is neatly done with copper bars and strips. The heavy bus bars are laminated. The bus bars and con-

ONE OF SEVERAL LARGE PULL BOXES ON THE CEILING OF THE BASEMENT.



THE CUT IS ABOUT ONE-QUARTER OF THE ORIGINAL DRAWING SIZE, GIVING A SCALE OF ABOUT TWO AND TWO-THIRDS FEET TO THE INCH.

necting bars are polished and lacquered. All studs are forged copper.

All copper conductors shall have an area of not less than one square inch for each 800 amperes. Switches and circuit breakers have on their movable contact surfaces not less than one square inch of surface to each 60 amperes.

All small wires are fastened to the marble with brass clasps. All ironwork, conduit, cables and circular loom about the switchboard is painted.

All circuits not provided with circuit breakers have fuse blocks for open-link fuses on the switches and on the front of the board. Distances between opposite polarities of all switches, circuit breakers, bus bars, etc., conform to the rules of the Board of Fire Underwriters for a 250-volt plant.

Feeders not running under the floor run to the top of the board in the shape of hard-drawn copper rods covered with neatly fitting circular loom conduit, and supported by porcelain insulators or slate fastened to iron bars properly secured. The rods terminate at the top in lugs which are bolted to similar lugs connected to the feeder cables. The rods are of the same size as the cables except that no rod is less than ⅜-in. diameter.

Above the switchboard, for a space about four feet in height, a box of one-inch white marble slabs is erected with marble front and ends and a bronze grille over the top with a marble cornice to finish the front and ends. In this box the feeders are run, making all the crosses and turns necessary. The feeders are firmly supported on angle-iron strips with split porcelain insulators.

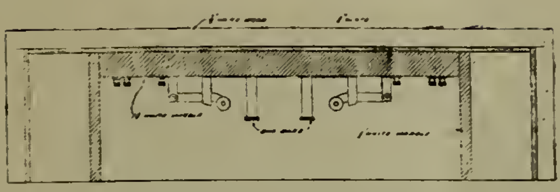
The space behind the switchboard is lighted by six key receptacles with polished copper finish, mounted on the wall equally distributed and controlled by a switch on the switchboard.

All cut-outs, switches and circuit breakers are built upon the marble of the switchboard without individual bases. Removable strips of marble under each set of fuses prevent blackening the board. All metal work on the face and back of the board is finished in copper.

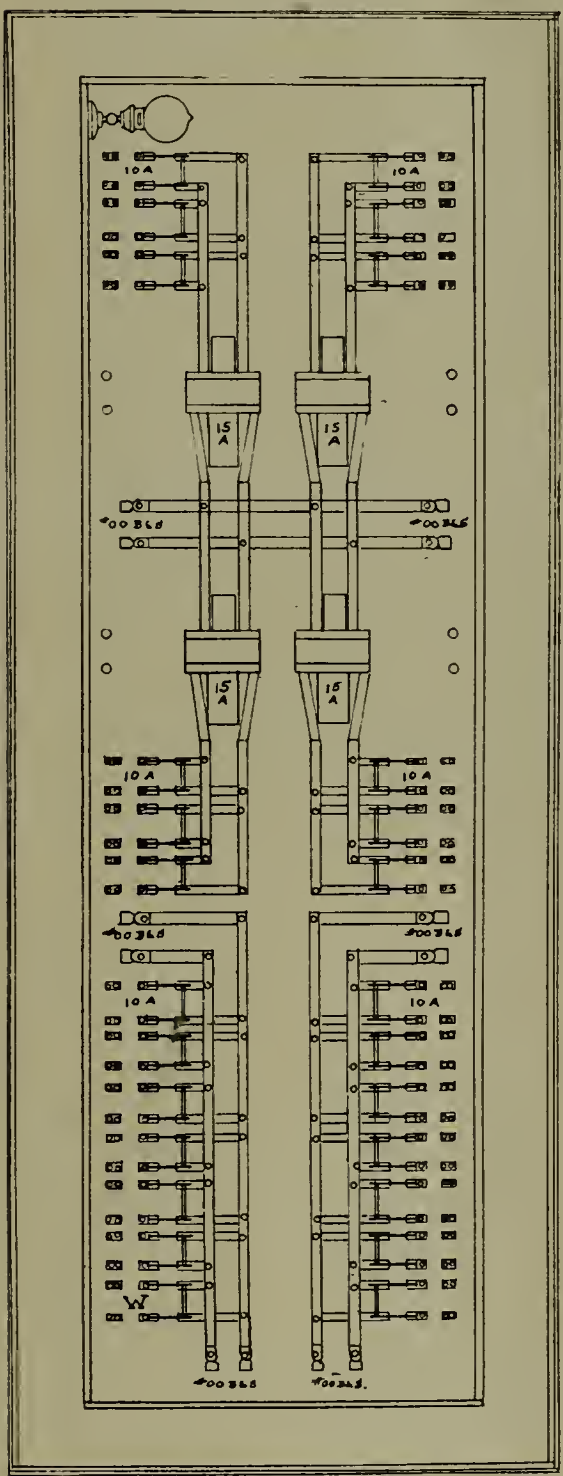
The switchboard contains the following 250-volt, double-pole, all-copper knife switches and fuses:

Seven 500 amperes for feeders Nos. 41, 51, 61, 71, 221, 231 and 281; four 400 amperes for feeders Nos. 42, 52, 62 and 72; six 300 amperes for feeders Nos. 11, 74, 101, 211, 261 and 271; 20 100 amperes for feeders Nos. 12, 13, 14, 17, 18, 24, 26, 27, 34, 43, 53, 63, 73, 102, 103, 106, 131, 201, 241, 251, and two for future use; 30 75 amperes for feeders Nos. 21, 22, 23, 28, 31, 32, 33, 35, 37, 44, 81, 82, 83,

·DETAILS·OF·DISTRIBUTION·BOXES·



TYPICAL SECTION OF DISTRIBUTION BOX



DIST. BOX #8-C
ROOM #116

86, 91, 92, 93, 95, 104, 107, 132, 141, 151, 153, 154, 161, 171, 181, 191 and 192; one 50 amperes for feeder No. 291, two for motors about engine room, and one for future use; and 13 25 amperes for feeder Nos. 15, 16, 25, 36, 84, 85, 94, 105, 111, 121, 122, 152 and 172, one for end cell switch, 23 for lights about engine room, two for motors about engine room, and six for future use.

The switchboard is illuminated by six three-arm copper electric brackets with half-round porcelain reflectors, green outside.

There is one double-pole double-throw switch connected so that the lights in the engine room and behind the switchboard can be thrown on the lighting bus bars or directly on the source of supply to the building. Immediately above this switch, a small red bull's-eye in copper rim set in the switchboard with two small lamps behind same in metal box and connected in multiple direct to the source of supply shows when the supply is alive.

A part of the conduit system is now in place. Conduit is loricated, made by the Safety-Armorite Conduit Company, Pittsburg, Pa.

It is installed in such a manner that all wire of each and every system may be run for its entire length in the conduit, and may be easily withdrawn and reinserted without disturbing any part of the building except the portion installed in connection with the electric system for that purpose. A separate system of conduit is installed for each system, that is, light, heat, power, clocks, fire-alarms, call bells and telephones.

The conduit is of proper size for all the wire to be inserted without damage, and, where for 250 volts systems, is not smaller than ¾-in. for all branches, ¾-in. for all sizes up to two No. 10 B. & S., one inch up to two No. 6 B. & S., 1¼ in. up to two No. 1 B. & S., two inches up to two No. 0000 B. & S., 2½ in. up to two 300,000 C. M., and three inches up to two 500,000 C. M. Conduits for low-potential cables have not less than ⅛-in. clearance up to one inch conduit, and $^5/_{16}$-in. in larger sizes.

All conduit is securely fastened to the building walls and ceiling independent of other pipes, pipe hooks or straps being provided every three feet and on either side of every elbow.

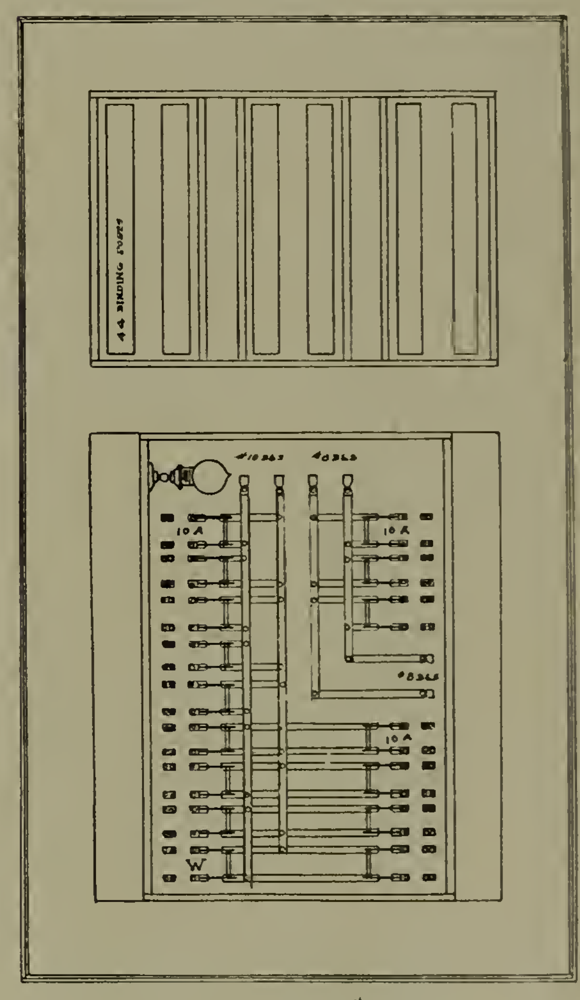
All joints are made with white lead, and there is no open space between the ends of the conduit inside of the couplings. All ends are cut square. All concealed joints are painted on the outside with two coats of white or red lead, after the conduit is in place. The conduit is made watertight.

When the conduit is run under marble, cork or tile floors, or at other points when exposed to the action of cement, it is covered with plaster of Paris. All exposed conduit is run in straight lines parallel with the walls. In the cellar, the conduit is carried on iron pipe hangers secured to the steel beams of the building. The hangers and conduit are painted with three coats of white lead tinted.

The conduit in the book stack rooms is run exposed and is sandpapered, filled, painted, rubbed down, painted and glazed white.

Conduit run to lamps on tables in the reading room is brass and is screwed into the cap of a floor receptacle under the table. The floor receptacle used throughout the building is the Knickerbocker, made by Thomas & Betts, 299 Broadway, New York.

Each distribution box consists of a ½-in. slate box inside of a box constructed of hardwood or heavy sheet iron braced with angles and fitted with lugs to receive trim. All boxes are thoroughly painted inside and outside with P and B paint, and lined with ¼-in. slate, leaving a space between inside and outside boxes not less than three inches on all sides, and with a common back of hardwood or iron similarly painted and lined with ¼-in. slate. Boxes in the cellar, attic and book stacks are of iron, all others are of hardwood. All distributing and



DIST BOX #3-A
ROOM #19

panel boxes are made by the Metropolitan Switchboard Co., 532 West 22d Street, New York.

Doors and finished trim on all boxes for the cellar and attic are of paneled sheet iron. A diagram and scale plan of circuits is provided inside of the cover of each distribution box, and is protected by a plate-glass cover fastened with coppered screws and leather washers. A thin cloth is stretched behind the glass to give a finish. All locks on boxes, cabinets or other devices containing electric equipment are master keyed.

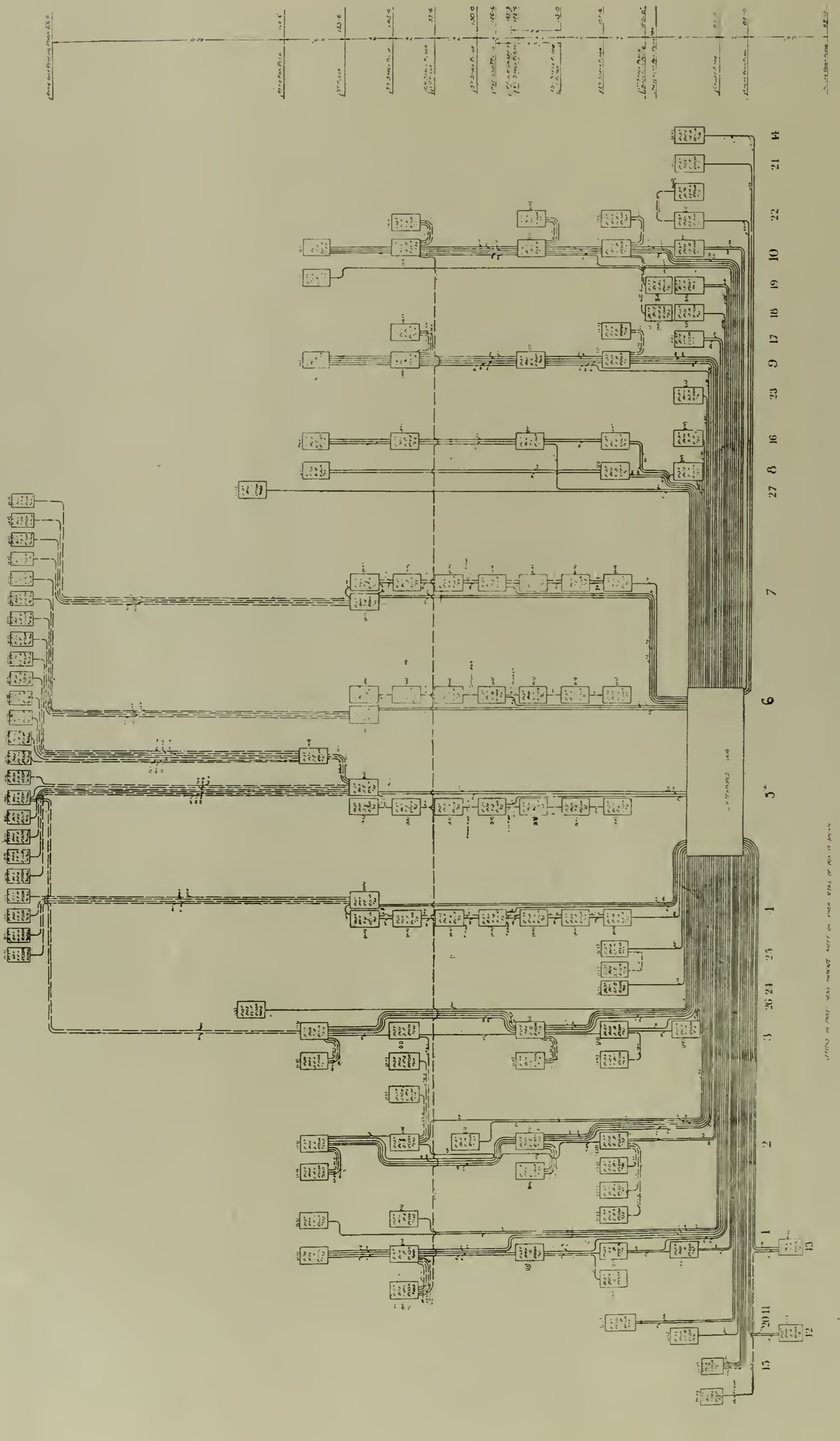


DIAGRAM OF FEEDERS

At all points in all low-potential systems where wires are distributed or terminate, connection boxes are installed, built and fitted the same as distribution boxes, and containing panels or connection strips having mounted upon them copper connecting terminals and binding screws.

At the points in the basement, where wires for public telephones, fire-alarms, messenger calls and other services from outside enter the building, boxes as described above will be placed in a separate compartment under separate lock and key for each company.

Pull boxes are placed where necessary. These are of sheet iron with iron bars and split porcelain insulators to hold the wires. They are subdivided for the several sections by iron partitions.

Conduits are brought in at the side of the boxes as near the back as possible. They end just inside the wooden box, and from this point the wires are carried in flexible tubing. All conduit ends are fitted with bushings to prevent abrasion.

The slate linings are bored from templates so as to fit the tubes accurately, and in many places templates are placed at the ceiling and floor to insure a straight run of the conduit into the box.

Conduit from the distribution boxes to the outlets is run on the loop system.

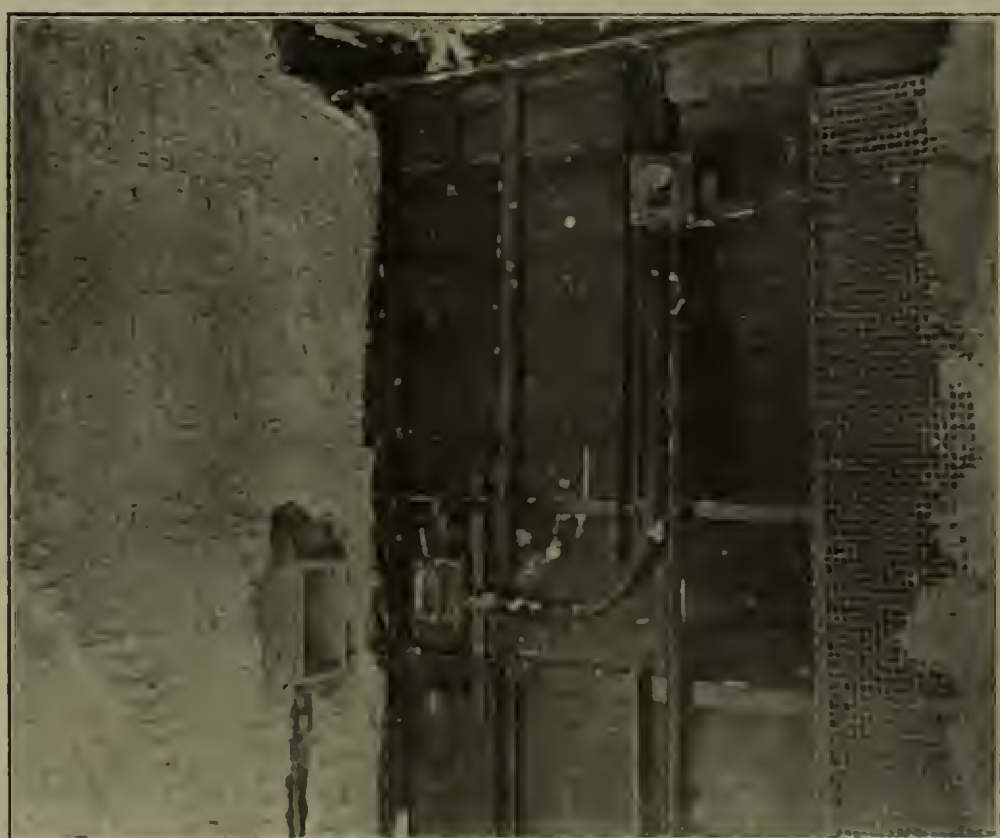
CONDUIT FOR CONTROL WIRES TO THE REMOTE CONTROL SWITCHES—A CONTROL PANEL WILL BE LOCATED AT THIS POINT.

Any point at which a wire or wires are brought to the surface for use or control is termed an outlet. At each outlet there is placed an outlet box made by Thomas and Betts, 299 Broadway, New York. Each side outlet box for lighting has a threaded fixture stud in the base to act as a fixture fastening. These boxes are securely fastened to the wall with expansion bolts and then cemented into the wall. At combination outlets a hole for gas pipe is made inside the stud. All outlet boxes are cemented into floor, wall or ceiling in addition to any other fastening.

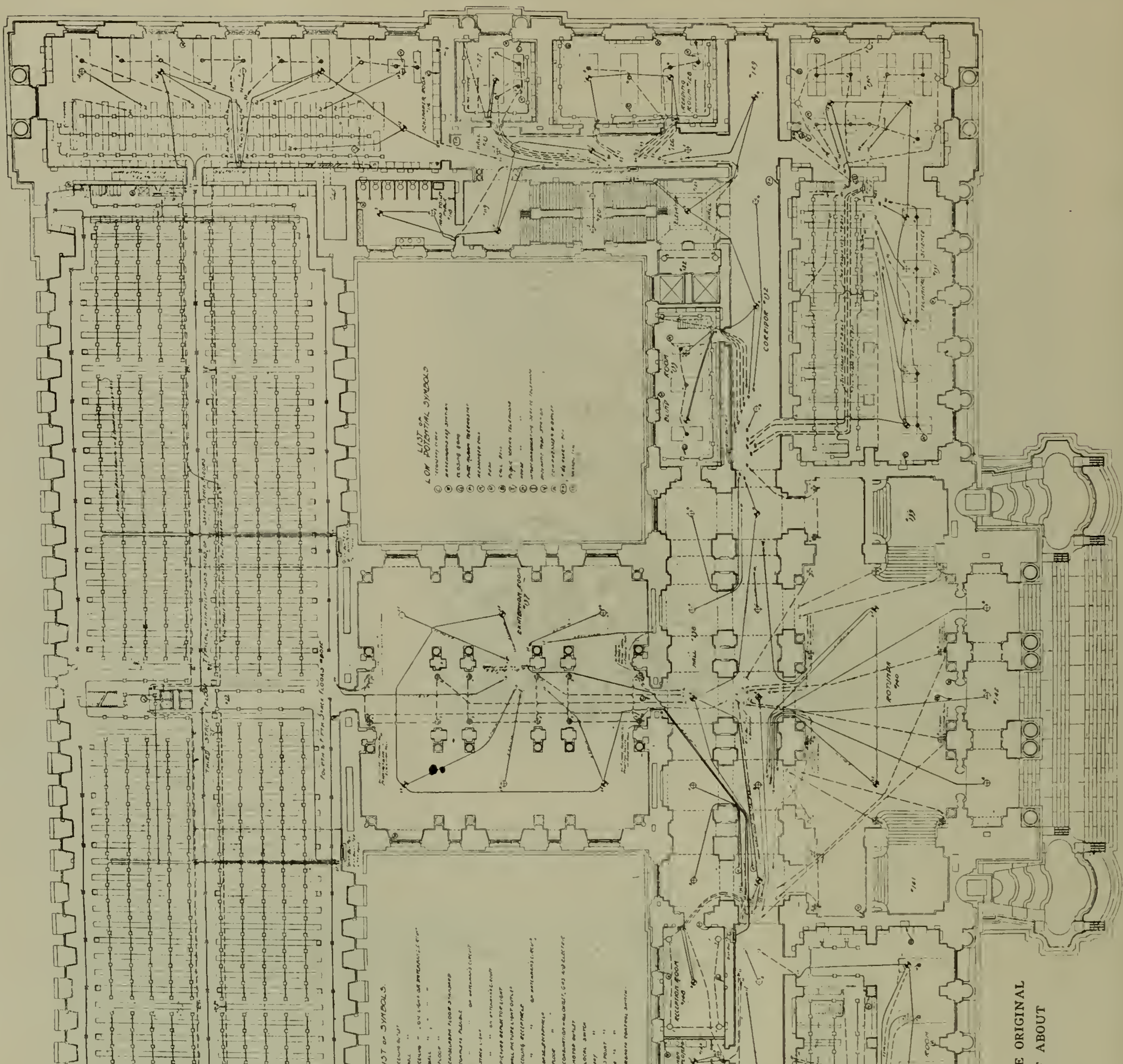
For each ceiling outlet there is provided a fixture hanger consisting of a T of ½-in. iron pipe anchored on the floor above, the top being 15 in. long and the vertical of a length to pass through the floor and leave an end for the insulating joint in the outlet box. The fixture fastening is secured to the floor above with two pipe hooks and covered with plaster of Paris, with which the space around the pipe going through the floor is also filled.

The fixture fastenings for the ceiling outlets in rooms 333, 313 and 331 consists of one-inch iron rod with two eyes at top, one split eye at the bottom and an iron saddle plate above the ceiling upon which rests an iron bolt passing through the lower of the top eyes. A small iron windlass and 75 ft. of ½-in. Swedish iron hoisting rope is provided for each of the ceiling fixtures in these rooms. At the bottom of the fixture hanger there is a railway strain insulator arranged to receive the fixture.

A narrow strip of marbleized slate having the necessary copper terminal blocks and connection screws for the wires from the fixture will be at each ceiling fixture in rooms 333, 313 and 331. The wires from the distribution box are connected to a similar terminal block with the copper terminals extending over the edge so as to exactly fit the terminals on the fixture. Dowel pins are provided so that the



WALL OUTLET AND SWITCH BOX.



LIGHTING PLAN
FIRST-FLOOR-PLAN.

THIS CUT IS ABOUT ONE-FIFTH OF THE ORIGINAL DRAWING SIZE, GIVING A SCALE OF ABOUT FORTY FEET TO THE INCH.

terminal blocks can only be put together in the proper manner.

The wires for lighting are of sufficient capacity to supply all the lamps in the building simultaneously with a loss of not more than five per cent. between the switchboard and any lamp. The difference between any two lamps will not exceed two volts. The voltage at the lamp shall be 235 volts.

All wire and cables are of the very best quality of copper, 98 per cent. conductivity, thoroughly tinned and insulated with a compound containing not less than 30 per cent. new pure fine para rubber, covered with two small-meshed braids thoroughly impregnated with a moisture-repelling solution, and finished on the outside with asphaltum polished. The wire, before the braids are applied and after 48 hr. immersion in water at 60° F., shows the following breakdown and insulation tests:

Size Wire B. & S. Gauge	Voltage	Insulation
14 to No. 0000	7,500	1,250 megohms
250,000 to 500,000 C. M.	7,500	1,000 "
550,000 to 1,000,000 C. M.	7,500	600 "
2,000,000 C. M.	5,000	500 "

The wire also withstands reasonable mechanical tests without break in the insulation.

All wires larger than No. 10 B. & S. are stranded.

Wires smaller than No. 12 B. & S. are not used. All branches for all systems of wires are run in parallel duplex wire. Each wire is taped separately and then they are taped or braided together.

In no case is wire pulled into conduit during the erection of the conduit. The wire is pulled in after the plastering is completed. The wire is of Standard Underground Cable Company's manufacture.

All switches for local control in the various rooms are the diamond H type made by the Hart Manufacturing Company, Hartford, Conn. The face plate is of dark statuary bronze of ample size to cover the outlet, and where there is more than one switch a gang plate will be installed, engraved to show the lights controlled by each switch. These switches will be placed on the knob side of doors at doorways.

From each of distribution boxes Nos. 1-C and 7-E two No. 12 B. & S. pressure wires will be run to the switchboard and connected to the voltmeter switches. Fuses are provided on the panels in the distribution boxes for these wires.

At each outlet shown on plans for a complete flexible there will be placed a porcelain ceiling block, brass canopy, reinforced flexible cord, key socket, shade holder and 10-in. porcelain shade, green outside, white inside. The flexible cord, except for boiler gauge lights, is of a length to bring the key of the socket within six feet and six inches from the floor. For the boiler gauge lights, half-round glass reflectors, green outside and white inside, will be set to throw the light on the gauges.

Remote control switches and pushes for operating them are located at numerous points for the efficient control of the lighting. All remote control switches are of the solenoid type with ample copper knife and jaw switch contacts, mounted on the marble slabs of the panels where located, and operated by push-button switches devised so that the current remains in the switch only long enough to operate the same and is then cut off. The switches are made by Pettingell Andrews Company, Boston, Mass. There are 24 remote control switches each of 25 amperes capacity and 196 of 15 amperes capacity each.

Push buttons for controlling these switches will be installed at near-by points as follows:

At six points in the lending delivery room, five points in the rotunda and portico, six points in the exhibition room, 12 points in the periodical room, eight points in the newspaper room, eight points in the technical science reading room, one point in the catalogue room, seven points in the document room, two points in the economics room, seven points in the applied science room, 58 points in the main reading room and stairways to attic, twelve points in the catalogue room No. 331, and at 350 points in the stack room.

The following motors are to be wired:

Room No.	Motor h. p.	Use.
10	1–2	Air Compressor
8	1–2	Drain Pump.
9	3–½	Motor Generators
9	1–12	Lift M
17	1–6	Dumbwaiter B
17	1–18	Exhaust Fan
17	1–8	Storage Battery Exhauster
17	1–2	Disc Fan
12	1–6	Book Lift A
18	2–10	Pneumatic Tube Exhauster
19	1–2	Disc Fan
46	9–1	Machine Tools
44	1–6	Book Lift C
22	1–15	Elevator L
22	6–6	Book Lifts I. J. K.
23	1–6	Dumbwaiter F
36	2–40	Passenger Elevators D
33	1–6	Book Lift E
Locker Room Floor:		
4	1–10	Ash Conveyor
Basement:		
52	5–3	Presses
99	2–3	Cutters
99	2–5	Presses
98	2–5	Presses
98	2–6	Presses
84	3.27	Fans
84	1–24	Fans
84	2–2	Air Compressors
Sixth Floor Stack:		
—	2–3	Book Conveyors G, H
Roof:		
410	2–5	Exhausters
408	1–5	Exhausters
406–a	1–8	Exhausters
406–a	1–10	Exhausters
406–a	1–6	Exhausters
406–b	1–5	Exhausters
403	3–5	Exhausters

For each motor throughout the building, except elevator motors, there is a double-pole, all-copper knife switch and a double-pole, double-coil, separate operating, laminated type circuit breaker enclosed in a hardwood or iron box lined with ¼-in. marbleized slate. The switch and circuit-breaker are mounted on a slab of white marble 1½ in. thick. This box is of proper size to contain all devices used for starting and operating the motor and to allow the door to be locked whether switch and circuit breaker are on or off.

There are also two motor generators each of 20 amperes capacity at 25 volts for operating the call bells, time clocks, closing gongs, fire-alarms, signals and telephones, and one motor generator of 10 amperes capacity at 25-40 volts for charging storage batteries for the above systems. The motors driving these generators are wound for 235 volts.

All the motor generators are set upon a brick base built on the floor of the engine room, with white enamel brick on the outside on sides and top and with bull-nosed brick for all angles. The foundations are of proper size for all of the motor generators, and the top is 28 in. above the finished floor.

There are also the following storage batteries each having a capacity of 10 amperes for eight hours:

One battery of 14 cells for general ringing service.

Two batteries each of six cells for central telephone talking circuits.

Twelve batteries each of three cells, for talking circuits of intercommunicating telephone systems.

The switchboard for the above consists of two slabs of 1½-in. polished slate mounted and equipped, finished and framed as described for the main switchboard, except that the angle-iron frame is to be fastened to the brick wall above the motor generators in the engine room. On this switchboard there are mounted the following:

One ammeter reading from 10 to 100 amperes for charging and discharging; one voltmeter reading from 0 to 25 volts with dial reading in ohms for testing grounds, one 24-point back connected voltmeter switch with name plate and connected to all dynamos, bus bars, batteries and grounds, also the switches, rheostats, etc., for the motor generators and batteries.

The work is being constructed under the direction of the architects, Messrs. Carrere and Hastings, 26th Street and Fifth Avenue, New York City. Pattison Bros., Fuller Building, New York City, are retained by the city as consulting engineers for all of the electrical work. The Lord Electric Company, 213 West 40th Street, New York City, are the contractors. We are indebted to Mr. Brainard, chief engineer of Carrere and Hastings, for the information given above.

Commercial Testing of Wire and Cable

F. M. FARMER

THE subject of testing wire and cable is one about which a great deal has been published, but, nevertheless, a review of the various tests which a commercial testing laboratory may be called upon to make under present-day specifications and a description of some of the methods used may be of interest. Wire and cable used for electric light and power purposes may be classified as follows:

- Bare
  - Copper.
  - Aluminum.
  - Alloy.
  - Bimetallic.
- Insulated
  - Rubber covered
    - Commercial 30%.
    - Marine.
    - Navy standard.
  - Lead covered....
    - Rubber insulated.
    - Paper "
    - Cloth "
  - Waterproof.
  - Magnet.
  - Special.

Tests on wire and cable are of two general classes—laboratory tests and factory tests. The former are made on short samples and on single lengths for the purpose of determining or checking the quality of the materials and the properties of the cable. The latter are made to detect defects and to see that the cable fulfils the specifications.

LABORATORY TESTS.

Conductivity.—Conductivity is a relative term and refers to an arbitrary standard which for many years has been known as "Matthiessen's Standard of Conductivity." At the time Dr. Matthiessen carried out the experiments on which he based his standard for pure copper, copper was not being made commercially as pure as it is now. Hence, it often happens that a conductivity of more than 100% is frequently obtained.

Since conductivity is the reciprocal of resistivity, it is only necessary to determine the resistance of the sample and its dimensions in order to calculate the conductivity. The standard practice is to cut samples about four feet long and measure the resistance of a length of one meter.

The resistance can be measured in several different ways. If the wire is of small diameter, No. 10 B. & S. or smaller, the resistance of an exact meter length can be measured on a Wheatstone bridge. It is then corrected to the standard temperature 20° cent., by applying the temperature coefficient for copper (0.0042 per degree cent.). The average cross section having been obtained from the length and specific gravity, the resistance at 20° cent. of a piece of pure copper of the same dimension is calculated. The ratio of the latter resistance to the former gives the conductivity. This method is in use in the Equipment Bureau of the Navy Department on wire and cable purchased for use on the naval vessels. The largest single wire, however, that is used either in a single conductor or in a cable is No. 11 B. & S.

When the sample is larger than No. 10 B. & S., the resistance can be more accurately determined by means of a Thomson double bridge, which is a special form of the Wheatstone bridge adapted to measuring low resistance. By means of this instrument the sample is compared directly with a standard resistance, the two being connected in series and carrying a current which is not large enough to heat the test sample.

Where approximate values only are wanted and the sample is long enough, the straight fall of potential method using a millivoltmeter and an ammeter can be used. If a potentiometer is available to measure the fall of potential, the resistance can be determined in this way with high accuracy.

In order to get the average cross section, it is only necessary to weigh the sample in pure water, which gives the volume and hence, knowing the length accurately, the cross section. However, in the larger samples of wire (No. 5 B. & S. or over), the cross section can be determined with sufficient accuracy from the mean of a series of measurements of the diameter made with a micrometer caliper.

These methods for getting the conductivity are, however, slow, and they involve the use of the temperature coefficient, and hence the measurement of the temperature of the test sample. It is desirable to avoid the latter measurement if possible, as the only satisfactory method is to immerse the sample in an oil bath during the test. A method in common use commercially is that making use of a form of the Thomson bridge known as Hoope's conductivity bridge. It requires fewer operations, is easy to manipulate and eliminates the question of temperature. The essential feature is the use of arbitrary copper standards representing pure copper. The samples are compared by the Thomson double bridge method with these standards, and the conductivity is read directly from a scale.

The apparatus used by the Electrical Testing Laboratories for this test is of this class, except that the conductivity is read off directly from the dials of a Thomson bridge. The operation is as follows: The weight of a known length (120 cm.) is first determined. The length of the sample, which if it was pure copper would have the same resistance as the standard, is then calculated from that of Matthiessen's standard metergram. The resistance of the standard is then compared with the actual resistance of this length of the sample by means of the Thomson bridge, and, by properly connecting the standard and the unknown, the ratio of the resistance as shown by the bridge dials reads in per cent.

Of course, in the actual operation, time-saving facilities are used. The sample is cut to a standard length of 120 cm. in a machine and, knowing the weight, the length required is obtained at a glance from a table previously worked out. Suitable holders with adjustable knife edge are provided for the standards and test samples so that the conductivity determination is a matter of only three measurements, and no attention need be paid to the temperature.

A method has not been mentioned which will serve for very approximate results. After determining the resistance either by the fall of potential method or a Wheatstone bridge, it can be compared with that of pure copper of the same gauge size as published by the American Institute of Electrical Engineers.

In the determination of the conductivity by these methods, it is assumed that the sample is homogeneous and that the cross section is approximately uniform. Otherwise the sample would not be representative, for these tests give the conductivity of the sample as a conductor and not as a metal.

The conductivity of samples of cable is best determined by measuring that of several of its strands selected at random and taking the average.

Copper.—In many cases, the physical properties of the conductor are of the greatest importance. This is particularly true in high-tension transmission work where the line construction is expensive and it is desirable to make the spans as long as possible. On this account, copper conductors, both solid and stranded with a steel-wire core, are being used in addition to the usual hard-drawn copper and copper alloys. Here high tensile strength is desired even at the sacrifice of some conductivity. On the other hand, other purposes require copper of low tensile strength but high ductility. Such is the case with magnet wire, bonding wire, railway signal wire, etc.

Tests for determining these properties are very simple. The tensile test is usually made in a machine built for the purpose, such as the one shown in Fig. 1. It consists essentially of a set of stationary jaws in the upper platform, and a set in the lower platform, which is movable. The former is supported on a system of levers, and is counterbalanced by the arm and weight shown to the right. The lower platform is caused to move downward when power is applied to the endless screws with which it engages, and thus the stress is applied to the wire and at the same time it is being weighed. The machine is power driven, and is under the entire control of the operator, who at the same time keeps the counterweight always balanced. The elongation is usually taken in a length of eight or 10 inches, and in ordinary tests on copper wire is measured by means of two scales sliding within each other. One is fastened at each of the works by a very light steel wedge.

Torsion tests do not, as a rule, require the measurement of the torsional strength but simply the number of times a sample can be twisted without breaking, and the number of times it can be wound around itself and then unwrapped without breaking. Both of these can be made by hand and the former can be made in a lathe or in a special machine similar to a lathe. In the twisting test, care has to be taken not to introduce a tensile stress by reason of the shortening of the sample as it is twisted.

Tinning.—The usual test for quality and depth of the tinning is to expose samples of the wire to hydrogen sulphide gas for a prescribed period (about three hours). Tin sulphide, which is black, is formed, and the depth of the color is an indication of the thickness of the coating. The test is also made by dipping the thoroughly cleaned samples in a sodium sulphide solution a prescribed number of times.

High-Potential Tests.—The National Electric Code test is to prepare samples about two feet long and arranged in a suitable vessel of water in such a way that one foot is immersed for 72 hr. Then 4000 volts are applied to the copper wire and the pan and

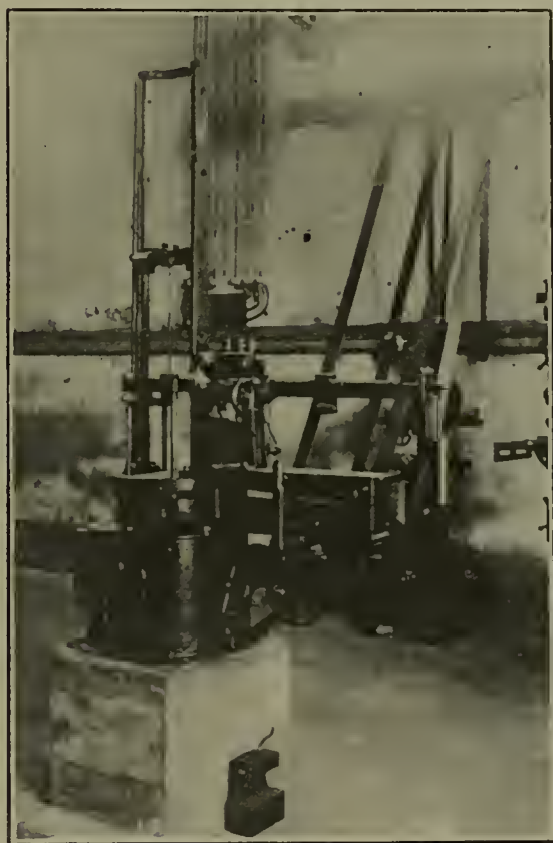


FIG. 1.—MACHINE FOR MAKING TENSILE TESTS.

held for five minutes. At the end of that time it is raised to 7000 volts and again held for five minutes. This is continued by 3000-volt steps until puncture occurs.

A satisfactory method of determining the dielectric strength of an insulation is to wrap several sections, each say six inches long, with tin foil about one inch wide wound on spirally. The potential is applied to the conductor and a piece of light copper wire twisted around each of these sections in turn. The sample is divided into several sections in order to get an average value of the dielectric strength and also an indication of its uniformity, for, if the entire sample were wrapped with tin foil, the puncture would occur at the weakest spot only. In investigations of lead-covered cables, the test is made on several short samples for the purpose just indicated. In the case of large cables, it may mean considerable money cost, since the samples have to be sufficiently long to permit cutting the lead back from the ends to prevent arcing over.

In connection with these high-potential tests, abnormal conditions are often introduced, such as bending some of the samples of lead-covered cable at right angles once or several times. Others are put in freezing mixtures, baked in an oven, etc., before being tested. These tests are usually made by applying the voltage at a low value and gradually raising it until puncture occurs.

There are several important details to be considered in high-potential testing. The testing transformer should be of ample size, so that its ratio will not be affected by any ordinary testing load that may be put on it. This load is, of course, in the case of lead-covered cables, the charging current required because of the electrostatic capacity. Another advantage of ample capacity is that the point of rupture is easily found.

Care should be taken in the method of controlling the voltage. Variable series ohmic or inductive resistance is very undesirable as it distorts the wave form, making it peaked, and thus subjecting the test sample to a higher voltage than the maximum corresponding to the mean effective value indicated by the voltmeter.

All the methods of measuring the voltage have objections. The most common is doubtless that using the ratio of the transformer and the indication of a voltmeter on the primary winding. This method depends evidently on the constancy of the ratio, which may or may not be affected in the way previously pointed out, assuming that its normal value at no load is accurately known.

The voltmeter is sometimes connected directly across the high-tension terminal in series with suitable resistance. This method means considerable lost energy besides using the capacity of the transformer for other than test purposes. Furthermore, it involves more or less risk to the instrument and the operator as well as possible errors on account of electrostatic attraction between the moving element and the case.

The spark-gap method of measuring the voltage is often used, but generally as a rough check. A spark gap between ordinary needle points gives very inconsistent results because of slight variations in the points, condition of the atmosphere, shape of the circuit leading to it, etc.

An electrostatic voltmeter in the high-tension circuit is probably the best method if it is correctly calibrated. These instruments require no energy, and can be obtained direct-reading as high as 200,000 volts. They can therefore be placed directly across the sample under test, which is always desirable.

Fig. 2 is reproduced from a photograph of the principal part of the high-tension testing equipment of the

Electrical Testing Laboratories. It consists of a 10-kw., 120,000-volt transformer with control apparatus and a testing cabinet. There are many testing transformers in use of a much higher capacity, but for testing samples and for general laboratory use, 10 kw. is sufficient. Fig. 3 is a diagram of the circuits in which AB is the low-tension winding, and $a\ b$, $a^1\ b^1$, $a^2\ b^2$, $a^3\ b^3$ are the four sections of the high-tension winding. The latter terminate at the end of long hard-rubber bushings about 30 in. long on top of the transformer, and are so arranged that they may be connected either in series or parallel. The two end terminals connect to the testing terminal in the upper part of the testing cabinet, which is about four feet from the transformer. The primary voltage is controlled by a variable ratio auto-transformer R, which was built at the laboratory. It consists of a large ring built up of iron wire about 27 in. outside diameter and six by six inches in cross section, and was formerly a field ring on a brush arc machine. The ring is wound with No. 5 B. & S. magnet wire, the surface of which on the inside of the ring is bare. A carbon brush attached to the end of a radial arm which turns on a shaft fixed at the center of the ring slides over this part of the winding. The line voltage is applied at the terminal t t^1, and any voltage from zero to the line voltage may be impressed on the primary winding by moving the arm. The shaft to which the latter is attached extends to the front of the cabinet within easy reach of the operator.

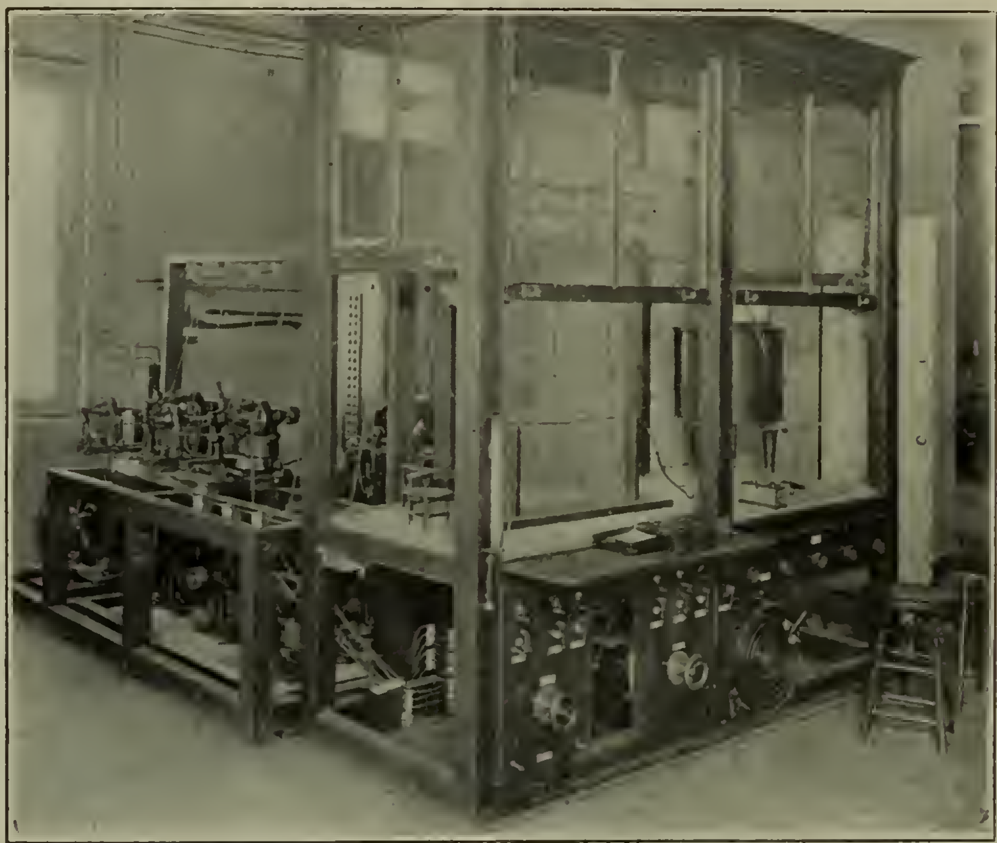


FIG. 2.—HIGH-TENSION EQUIPMENT.

A Kelvin electrostatic voltmeter, E, oil damped is connected permanently to one section of the high-tension winding. It indicates the total voltage on the test sample when the sections are in parallel and one-fourth when they are in series. A Weston alternating and direct-current voltmeter, V, is also always kept connected to the primary of the transformer as a check on the electrostatic instrument.

In addition to this 10-kw. transformer, the laboratory has several smaller ones, including three ½-kw., 10,000 volts, and three 1-kw., 2000 volts. There is also a set of five 2000-volt, direct-current generators (shown at the left of Fig. 2). These are driven from one motor and are connected in series so that 12,000 volts total is obtainable. The outfit is used to make tests in comparison with alternating current on insulating materials, including wire of low dielectric strength. Its principal use is, however, in connection with a piece of apparatus which is unusual and which is sometimes made use of in wire tests. This apparatus is shown in Fig. 4, and consists of 10 plate-glass condensers each being a single plate of glass about 24 in. sq. with a sheet of tin foil about 20 in. sq. pasted on each side. A wooden shaft extends from one end of the frame to the other, and to this are fastened four sets of radial spokes or arms. Two sets which are diametrically opposite serve as supports for wires, and fine brass wire brushes arranged in such a way that twice per revolution of the shaft the condensers are connected in parallel and to the charging terminals. The other two sets provide the series connections so that twice per revolution the plates are all connected in series and to the discharge terminals. The five 2000-volt machines which were referred to above are connected to the charging terminals so that the condensers are charged in multiple twice per revolution at 12,000 volts and discharged in series twice per revolution, giving probably about 120,000 volts. The apparatus is virtually a direct-current step-up transformer which will give about a 10-in. spark at 250 rev. per min., which is oscillatory and, according to the accepted theory, of the nature of a lightning discharge. This apparatus is, therefore, used in conjunction with the testing transformer to study the effect on the dielectric strength of static discharges through the insulation of wire, cable, etc.

Rubber. — Physical and chemical tests are not, as a rule, required by engineers on paper or cloth insulated cable, although some simple visible test may be made by the manufacturers as a check on the quality of the paper or cloth before it is made up into cable. On rubber insulation, however, these tests are of great importance, as little can be determined by mere inspection.

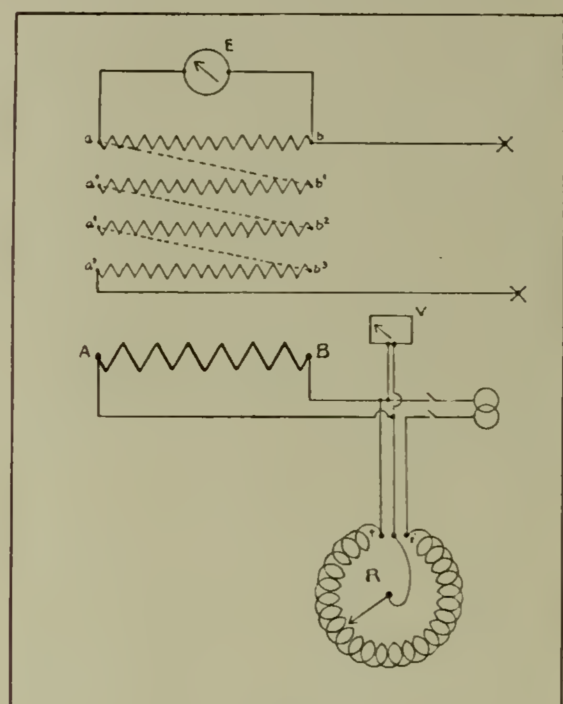


FIG. 3.

The object of the chemical analysis is principally to determine the percentage of pure rubber, of extractive matter and of sulphur, both free and combined. The value of the rubber as an insulator depends on the amounts and proportions of these ingredients.

A certain amount of pure rubber is required to give the necessary waterproof qualities, flexibility, etc., but it alone is a very poor insulator. The addition, however, of the proper amount of sulphur under heat makes it an excellent insulator, but the amount of sulphur and degree of heat (vulcanization) must be just right to get good results. If too little sulphur is added, the compound will be low in dielectric strength and weak mechanically. On the other hand, an excess will either make the compound too hard or remain uncombined after vulcanization, in which case the process will gradually continue causing the compound to eventually become hard and brittle. The amount of extractive matter is indicative of the probable quality of the original rubber, the best goods showing the least amount of extractive matter, as a rule.

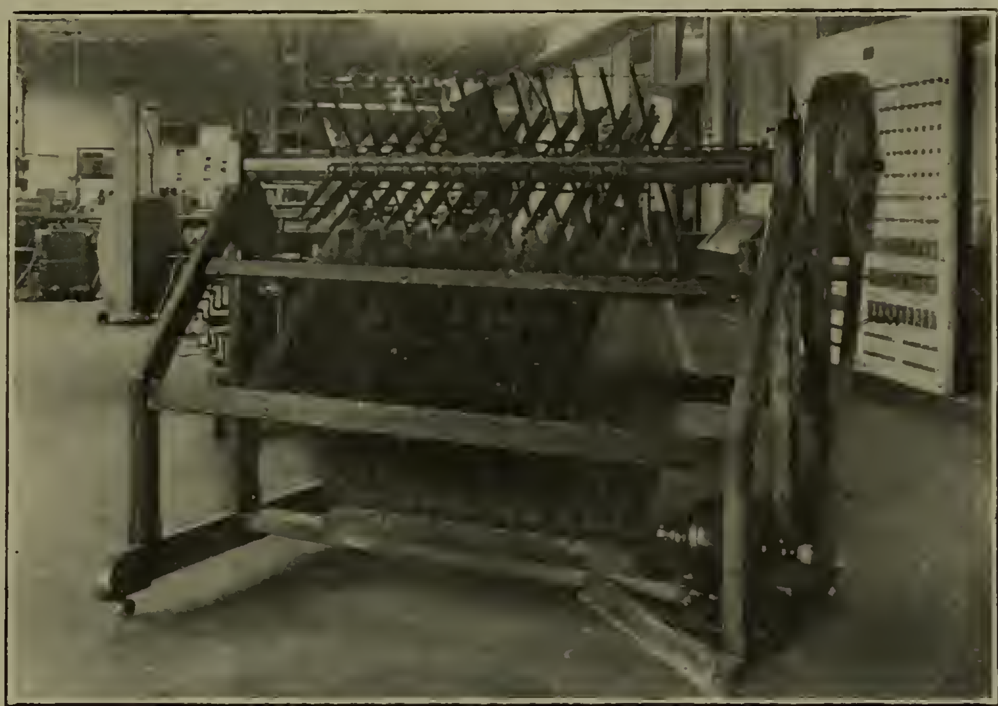


FIG. 4.—CONDENSERS ARRANGED FOR PRODUCING A HIGH VOLTAGE.

The methods used in making these tests being purely chemical ones need not be discussed here. Suffice it to say that the analysis of rubber compounds is difficult and slow and requires a high order of skill and much experience.

Physical tests are made on rubber compounds as a check on, and often as a substitute for, the more slow and expensive chemical analysis. These tests consist simply of a determination of the tensile strength, the permanent set after stretching a prescribed amount for a given time and the rapidity of recovering after having been stretched. High tensile strength is usually indicative of high dielectric strength, and the other tests show whether or not this has been obtained at the sacrifice of elasticity—a necessary property from a mechanical standpoint.

A special tensile testing machine is manufactured for making these tests although rough results, sufficiently accurate for the purpose of determining compliance with specifications, can be obtained on an ordinary testing machine such as the one described in connection with tensile tests on copper wire. The special machine is horizontal and is provided with special jaws, a spring balance for weighing the stress and a scale on the bed frame for measuring the elongation. The sample, which is usually cut six inches long and from ⅛-in. to ½-in. wide, is placed in the machine and two marks two inches apart are placed on it at the center. The jaws are moved apart at a constant and prescribed rate. The zero of the scale, which is two posts which slide past each other like a slide rule, is kept opposite one mark and the other end is kept opposite the other mark as the sample stretches. From the indication of the spring balance, which is between one jaw and the point of application of the power, and the original cross section of the sample the stress per square inch at rupture is known. The scale reading shows the elasticity. The permanent set is determined on another sample marked in the same way.

Moisture absorption.—This test is not generally made on rubber insulation, to wire covered with saturated paper and cloth, or to that not intended to be waterproof. It is intended to indicate the waterproof qualities of the braid on rubber-covered wire, and of the insulation on weatherproof wire. It consists in cutting a small sample about six inches long and, after dipping the ends to a depth of about ⅛-in. in hot paraffine, carefully weighing it on a chemical balance. The sample is then immersed in water one or more days, according to specifications, and then weighed again after removing the excess moisture by means of filter paper. The braid is then removed and the remaining copper wire (or copper wire and rubber insulation if the sample is rubber-covered wire) is weighed. From these three weighings the moisture absorbed by the braid expressed in percentage can be determined. In comparative or exhaustive tests, the samples are alternately soaked in water and baked in an oven until the waterproof qualities are destroyed, the object being to imitate outdoor conditions.

There are, of course, other tests than those mentioned, usually of a special nature and on conductors for special purposes. These would include tests to determine the effect of freezing, acids, alkalies and fire-proof qualities. Conductors of a new kind require tests for carrying capacity, and those with steel cores require investigations as to the impedance at various frequencies, current densities, spacings, etc.

Tests on Whole Lengths.—Tests of this class are for the purpose of determining the properties and qualities of the wire or cable as such. They include: (a) insulation resistance and its temperature coefficient; (b) electrostatic capacity and its temperature coefficient; and (c) sheath and dielectric losses in lead-covered cables on alternating current.

(a). The most common method for measuring insulation resistance is the

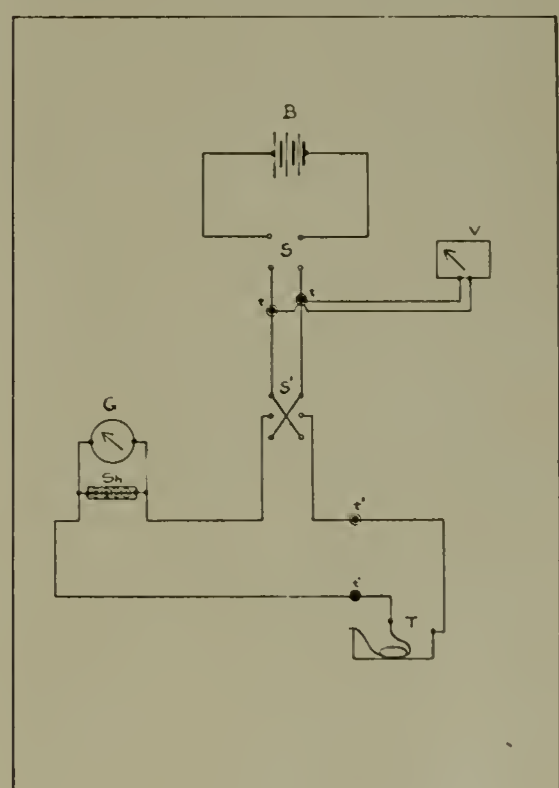


FIG. 5.

direct deflection method in which the resistance to be measured is compared with a standard. In Fig. 5 is shown a diagram of the arrangement of the outfit used by the Electrical Testing Laboratories. The only unusual feature is the use of a storage battery instead of the usual silver chloride battery. This battery indicated by B consists of 150 ¾ ampere cells mounted on a shelf which is hung from the ceiling. To insure high insulation, each glass jar was dipped in hot paraffin before assembling, and a layer of paraffin was floated on the surface of the electrolyte. Each tray of 10 cells is carefully insulated from the shelf and the latter from the building by the use of insulating trolley strains. When in use, the battery can be completely disconnected at its terminals from the charging lines.

The switches, galvanometer scale, etc., are mounted on an alberene stone table and the switches and binding posts are furthermore mounted on rubber posts. The switch S disconnects the battery from the table, S^1 is the usual reversing switch and *t t* are binding posts for voltmeter connections. Those marked t^1 t^1 are on rubber posts which extend below the table as well as above; the lower terminals serve for convenient connection to the wire and the portable tank T, while the upper terminals are for the connection of the standard resistance and for use in tests on materials other than wire. The galvanometer G is connected to the table by wire supported in air by silk cords and glass insulators. The procedure is to note the deflection of the galvanometer with the standard megohm in circuit instead of the wire using the testing voltage and a suitable shunt value on the galvanometer. This is repeated with the wire in place of the standard and then having multiplied the deflections by the shunts used, if any, the resistance is simply the former divided by the latter. The resistance per mile equals the resistance as found divided by 5280 ft. and multiplied by the length of the sample in the water expressed in feet.

In tests to determine the temperature coefficient, the insulation is simply measured at several different temperatures. The latter must be kept constant several hours (depending on the size of wire, etc.) before a measurement is taken, and it must also be kept uniform. This is best accomplished by heating (or cooling) the water in a separate vessel and allowing it to flow into and out of the testing tank at a uniform rate.

Several precautions are necessary in making insulation resistance tests. In order to avoid leakage over the ends of the wire, the braid (or lead in the case of lead-covered wires) should be cut back from the ends at least three inches, and then these ends should be dipped in hot paraffine. The wire or cable should be thoroughly discharged before making a measurement. In the case of the ordinary rubber-covered wire, where the electrostatic capacity is small, the residual charge can be best gotten rid of by charging first in one direction and then in the other, and gradually decreasing the time of charge until the reversals are as rapid as possible.

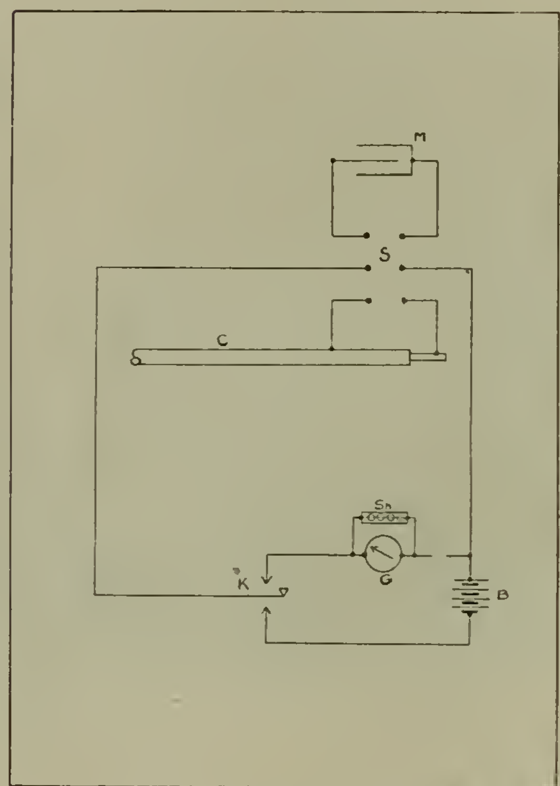


FIG. 6.

After such treatment the wire is usually in a neutral condition.

The apparent resistance decreases with time of application of the voltage and with increasing voltage. Hence it is customary to specify these conditions and also the period of immersion and temperature at which the test is to be made.

(b). Electrostatic capacity determinations are made in a manner similar to that used in insulation resistance tests. The capacity of the cable is compared with that of a standard condenser by comparing the deflections of a ballistic galvanometer obtained on discharging each. A diagram of the usual arrangement is shown in Fig. 6 where M is the standard condenser, S a double-pole, double-throw switch, C the cable, K a double-contact, quick-action spring key, G the galvanometer and B the battery. With the cable thoroughly discharged by connecting the conductor and lead together for a few seconds, the procedure is as follows: Switch S is thrown downward and key K is pressed down for the specified number of seconds, depending on the size of the cable, thus charging the cable. The key is then released and the deflection of the galvanometer noted. The same is done using the condenser. Having determined the correction for the leads, etc., by trial with the condenser and cable, respectively disconnected, the capacity of the cable is the ratio of the cable deflection to the condenser deflection multiplied by the capacity of the condenser. The capacity per mile would be the quantity divided by the length of the cable in feet, and multiplied by 5280.

Insulation is, of course, equally as important in this test as in the insulation resistance test and all of the switches, keys, battery, etc., are thoroughly insulated.

It is desirable in this test to keep the two deflections about of the same magnitude in order to eliminate the effect of personal error of observation and also the possible error due to non-proportionality of the deflections. To accomplish this, the condenser is made subdivided and in addition a dial switch on the battery for varying the number of cells is sometimes used. The use of the latter for controlling the deflection is furthermore preferable to the use of the galvanometer shunt. A galvanometer shunt will divide a steady current in the ratio indicated on it, but on account of its inductance it will probably not do so on capacity currents which are oscillatory.

The temperature coefficient is obtained, as in the case of insulation resistance, by measurement at various temperatures.

(c). In single conductor lead-covered cables carrying alternating current, the sheath will have induced in it eddy currents, which represent lost energy. There will also be a loss in the dielectric due to a capacity hysteresis effect similar to magnetic hysteresis in iron. These losses are, as a rule, comparatively small, but the amount of the dielectric loss is an indication of the quality of the dielectric and is often of importance in comparing different cables. The sheath loss does not exist, of course, in concentric and polyphase cables, since in those cables the fields produced by the individual conductors neutralize each other.

The sheath loss can be measured by first passing alternating current of the desired frequency and magnitude through the conductor of the cable and then direct current of the same magnitude. The watts, amperes and volts drop in the cable, are measured in each case by suitable instruments and the difference between the two wattmeter readings will be the sheath loss. The dielectric loss at such low voltages would be nil.

For measuring the dielectric loss, the potential is applied to the lead and the conductor with a wattmeter connected in the usual way. Since the voltage is high, the instrument must be protected and static charge errors must be eliminated by the use of grounds properly placed.

Both of these measurements require special instruments. The first measurement deals with very small voltages while the second one deals with small currents and in addition a low-power factor.

FACTORY TESTS.

Factory tests refer to tests made at the factory by a representative of a testing laboratory or a consulting engineer in the interest of the purchaser, and are made in accordance with the terms of the contract to show whether or not the wire complies with the specifications and to insure freedom from mechanical or structural defects. The class of tests already described is, as stated, for the purpose of determining the qualities, properties, etc., of the wire and the material of which it is made.

There are usually three tests specified in the specifications, and all of the wire or cable must show certain prescribed results before it is accepted. As every reel or coil has to be subjected to these tests, it is obvious that they should be made at the factory, not only on account of the expense of handling which is saved, but the facilities are right at hand for making repairs or replacements, thus saving time.

The tests usually made are insulation resistance, high potential and electrostatic capacity. The latter is, of course, made on lead-covered cables. The usual procedure is to make the high-potential test first, thus eliminating the defective coils at once by the application of the prescribed voltage, which depends on the thickness of the insulation, for a period varying from five minutes to an hour. The transformer should be checked first by a portable voltmeter in the low tension and a spark gap in the high tension.

If the cable is lead covered, the capacity test is made next to avoid the charge left by the insulation test. It is generally made by the method described above—several or all of the coils being connected together, lead to lead and copper to copper—thus saving time. This can only be done where the individual coils are uniform and in fact is only permissible under such conditions. Care should be taken in this test that the cable has stood in the room long enough to insure that it is at room temperature, which temperature has to be used in correcting the results to the standard of 60° F. When the cable comes from the lead sheathing presses it is very hot and in that condition would show a very low capacity. It should stand several hours before being tested.

Insulation resistance measurements are also generally made by the method described previously and are usually made last. Here also several coils may be connected together, but in this case it is safer because the total insulation will be determined by that of the weakest coil. If the wire is rubber covered, it is immersed in water a prescribed period before the test is made, and the temperature of the water is noted at the time of the test in order to correct the results to the standard, which is 60° F. Lead-covered cables are, of course, tested between copper and lead and do not need to be immersed in water. The same precaution in regard to temperature that was pointed out in connection with the capacity test should be observed here.

As the braid on rubber-covered wire contributes nothing to the insulation value of the rubber compound, the insulation test at the factory is made before its application. This facilitates repairs in case defects show up and also hastens the handling of the wire as it dries much quicker. There is, however, no assurance that the wire will not be injured in handling and braiding before it is finally shipped, but the chance is small and the practice is permitted by most specifications.

The paraffining of the ends of the coils, which was mentioned in connection with laboratory tests, would be altogether too slow and troublesome for factory tests where rough results only are required. The ends of the wire are dried by the flame of an alcohol lamp just before testing. Such a flame leaves no residue of carbon, which is a conductor on the wire.

After the tests are completed and samples are cut off for the laboratory tests, the accepted reels are sealed either by a small lead seal or by stamping the wire, flattened at the end of the coil, with a suitable steel die.

SPECIFICATIONS—RUBBER-COVERED WIRE.

	Set No. 1	Set No. 2	Set No. 3
COPPER (See Note 1).			
Conductivity, minimum	....	98%	98%
RUBBER COMPOUND.			
Chemical: Para, maximum	....	50%	33%
minimum	30%	40%	30%
Extractive matter, maximum	5%	....	6%
Free sulphur, maximum	....	0.2%	0.7%
Physical: Tensile strength, minimum	800 lbs. per sq. in.	1,000 lbs. per sq. in.	800 lbs. per sq. in.
Elasticity, minimum (See Note 2)	2" to 8"	2" to 7"	2" to 9"
Permanent set, maximum (See Note 3)	⅜" in 2"	1" in 2"	⅜" in 2"
Resistance: Period of immersion minimum	36 hrs.	24 hrs.	48 hrs.
Temperature	60° F.	72° F.	60° F.
Test voltage, minimum	100	200	150
maximum	500	....	....
Period electrification, maximum	1 minute	....	1 minute
Megohms per mile, minimum (See Note 4)	500 to 5,000	800 to 1,000	1,200 to 2,100
High Potential Test: Test voltage, minimum (See Note 5)	2,000 to 25,000	....	4,000 to 10,000
Time, minimum	1 minute	....	5 minutes
BRAIDS.			
Moisture Absorption: Period of immersion, minimum	....	....	24 hrs.
Temperature	....	....	70° F.
Per cent, maximum	....	....	10%
Heat Test: Not affected by	....	200° F.	200° F.

Note 1. The Signal Association specifies the following physical requirements: Each solid conductor must stand elongation from 10 inches to 12½ inches without breaking. It must stand 30 twists in six inches before breaking and must be capable of being wrapped six times about its own diameter and then unwrapped, the process to be gone through twice without breaking.

Note 2. A section in the middle two inches long must stretch to the lengths given without rupturing.

Note 3. Specifications 1 and 3 state that the two-inch section in the middle, when stretched to six inches and released immediately, must not be over 2⅜ inches long after one minute. Specification 2 requires that after the application of 900 lbs. per sq. in. for ten minutes the "two-inch section" must not be over three inches long ten minutes after release.

Note 4 and Note 5. These values depend on the size of the wire and thickness of insulation. For the same thickness of insulation, they are highest for the smaller size and *vice versa*.

Some of the more important requirements of three recognized standard specifications are given in the accompanying tabulation. These apply only to rubber-covered wire for use on low voltages, 500 volts or less. For other purposes, the specifications vary with the conditions to be met.

Set No. 1 is from those specifications known in the trade as "30 per cent. rubber insulation." It is standard commercial wire which is made by all of the leading manufacturers. Set. No. 2 is from the Bureau of Equipment, Navy Department, and Set. No. 3 is from the specifications of the Railway Signal Association.

Joint Construction Pole Lines

H. B. GEAR

General Inspector Commonwealth Edison Company, Chicago, Ill.

THE rapid extension of telephone and electric light distributing systems in recent years has caused the erection of pole lines on many of the principal thoroughfares of our American cities. In many cases all the available space for such lines has been occupied and this has resulted in a badly tangled condition of poles, wires and service drops. The situation is further much aggravated in some cities by the presence of two telephone systems, thus making three claimants for space in the public streets and alleys.

In the average American city there are, therefore, two or more pole lines in most of the principal streets and alleys with service drops from each passing over, through and under the other in a very unsightly and dangerous manner. These conditions are especially bad in alley construction, where the pole lines are necessarily close together and the opportunity for proper clearance is very limited. This is illustrated by Fig. 1 in which telephone and lighting services must cross the mains of the other company.

The increasing danger of such conditions as these has led the lighting and telephone companies in some cities to enter into arrangements for the joint use of pole lines. This policy has been further encouraged by municipal authorities who are desirous of keeping the number of poles on public thoroughfares down to a minimum, in response to an increasing public sentiment favoring the removal of poles from streets.

Joint arrangements have been in effect in the city of Chicago between the lighting and other companies for the past eight or nine years, with the result that a comparatively small part of the distributing systems of the lighting and telephone companies occupy separate poles on the same street or alley at the present time. The general nature of this construction is shown by Fig. 2, which illustrates congested conditions. It will be noted that the lighting wires are carried on the top of the pole with a clearance of five feet between the lower cross-arm of the lighting company and the upper cross-arm of the telephone company. The lighting company's transformer is allowed to encroach on the clearance space, provided that at least 3½ ft. is maintained between the bottom of the transformer and the top telephone wire. Ground wires on secondary lines and lightning arresters are covered by a half-round wood molding for the protection of linemen, as well as to prevent the possibility of any stray current being communicated from the ground wire to the telephone system.

The telephone company limits its open-wire equipment to two cross-arms and a service buck-arm in outlying districts and to one cross-arm in the more congested districts. Cables are used for the transmission up to within a block or two of the location of the telephones served. This avoids the necessity of extra cross-arms for through lines and greatly reduces the possibility of crosses with lighting services or high-tension wires. The lighting services being taken off above the telephone wires cannot pass through or under a telephone line and are, therefore, not likely to become crossed with the telephone wires. Being the stronger, they are not so likely to break and fall across the telephone lines, as would the telephone lines be to break and fall across the lighting lines were they run above. A clearance of two feet is maintained on the sides of buildings between lighting and telephone services. Where

FIG. 1.—SHOWING TELEPHONE AND LIGHTING SERVICE CROSSING THE MAINS OF ANOTHER COMPANY.

An address delivered before the Western Association of Electric Inspectors at the annual meeting at St. Paul, Minn., October 23, 1907.

underground lighting cables are brought up a pole the iron pipe is extended to the top of the clearance space, thus safeguarding the telephone linemen and minimizing the danger of a cross between the lighting and telephone wires.

This is illustrated by Fig. 3.

The major portions of the distributing systems of the lighting and telephone companies in Chicago is carried in alleys, owing to the existence of a very general alley system, which makes it unnecessary to utilize the streets except for through lines. The through lines are, in many cases, carried underground on the streets with lateral connections at alley intersections for the distributing lines.

There is some advantage to both companies in joint-pole arrangements from the standpoint of investment. The equipment of the two companies may be carried on one 35- or 40-ft. pole instead of on two 30- or 35-ft. poles in case the lines were not joint. This saving amounts to approximately 20 or 25 per cent. of the investment in overhead lines in cases where new lines are being built. But in cases where either company desires to extend its lines along routes already occupied by the other company, it is usually necessary for the company which desires to make the extension to do more or less reconstruction work. Where poles must be replaced in order to secure sufficient height for the wires of both companies, the expense incurred by the original company in transforming its equipment from the old to the new poles must be borne by the new company, and the cost of the line usually amounts to about what it would have been had the new company constructed a new line on the other side of the thoroughfare. There is little saving in investment to either company in such cases. The telephone system usually precedes the lighting systems in growing sections and unless the lighting company can forecast its requirements in such a way as to be able to take ownership in poles before it needs them, it must stand the expense of providing space on the telephone poles by lowering the telephone equipment or replacing the poles.

The operating advantages are, however, considered such by the Chicago companies that in all such cases the old line is reconstructed in preference to erecting a second line on the opposite side of the thoroughfare.

The use of joint pole lines has, however, some objections which may not be overlooked. The service of each company is likely to be interfered with by the employees of the other company, who may be engaged in construction or repair work in which they may carelessly or ignorantly cause injury to the equipment of the other company. It is, therefore, essential that the relation between the employees of the companies interested should be friendly, and a spirit of forbearance must exist at all times.

FIG. 2.—EXAMPLE OF JOINT CONSTRUCTION POLE LINES—CONGESTED CONDITIONS.

The details of the business arrangement covering the erection of new lines and rearrangement of old lines are very numerous and at times perplexing. When once established, however, the various employees interested may be given a policy to follow which can be carried out without undue friction.

The arrangement in effect in Chicago may be outlined briefly as follows:

Each company, when it proposes to make any extention of its lines, notifies the other company by letter of its intention, giving a description of the number, size and location of the poles which it intends to erect. Several copies of these letters are passed between the companies, so that each situation may be looked over by a solicitor or inspector, who makes a recommendation as to whether or not he considers it advisable for his company to take an interest in the poles which are to be set. If the other company desires larger poles it may ask for the same and they will be set as requested by the other company. Payment is then made on the basis of the number of gain spaces reserved for the use of each company.

If the other company does not feel that it will require space on the poles within a reasonable time, it reserves the privilege of refusing to take an interest in the poles which are to be erected.

In case one company wishes to extend its lines where the other company already has a line, it will ask for space on the existing poles, if they are high enough, and will attach its equipment after agreeing to purchase from the other company an interest in the poles concerned. In case of the lighting company, however, it must stand the expense of the other company lowering its equipment in order to provide space for the lighting wires at the top of the pole. In case the poles in the existing line are not tall enough for the equipment of both companies, the incoming company replaces the existing poles at its own expense, taking the old poles as salvage, and paying the other company the expense incurred by it in transferring its equipment from the old to the new poles. The new poles are then jointly owned by the two companies.

The expense of maintenance of joint poles is shared by the two companies in proportion to their interest in the pole.

In cases involving reconstruction work, and in cases where either company proposes to do new work where separate parallel lines exist, representatives of each company meet on the ground and agree upon a suitable arrangement for the consolidation of the existing lines into one joint line. In such cases, each company stands its proportion of the expense of the new work and transfers its equipment from the old to the new poles at its own expense.

In general, the lighting company is apt to bear the greater portion of the expense, owing to the fact that it must pay for the lowering of the other company's equipment and also because the lighting lines are usually preceded by telephone lines so far that the lighting company cannot forecast its requirements with sufficient accuracy to derive the benefit of taking an interest in the poles when they are originally set.

The safety to the lives of employees and the public, as well as the diminished fire risk, are well established by the fact that less than one serious case of trouble per year has occurred in seven years of operation of joint lines. This record has been made on lighting and telephone systems, which have been rapidly extended until there are at the present time about 25,000 poles jointly occupied by the wires of the Chicago Lighting Company and the Bell Telephone Company.

Joint arrangements are also in effect on about 2500 poles with the city, telegraph and street railway companies. In addition to this, the city of Chicago has the privilege of attaching its wires for electric light, fire-alarm and police telephone purposes to the poles of the lighting and telephone companies. It is, therefore, frequently necessary to provide space on the upper part of a joint pole for the lighting wires of the city and on the lower part for the fire-alarm and police telephone systems. In general, all signaling systems are kept on the telephone company's portion of the pole, and all lighting or traction systems on the lighting company's portion of the pole.

Cases of triple occupation in which the city is the third party are numerous, but triple occupation with other companies is not frequent.

The writer realizes that methods which can be applied in metropolitan work are not always suitable for smaller cities on account of the limited financial resources of the companies involved, which prevent the use of underground work to any great extent. In cities where the main runs cannot be carried underground, separate routes on high poles should be established for these by each company, and the distributing lines which it may be necessary to have strung along these routes may be carried well below the through lines.

As far as possible, the through lines of the telephone company should be carried in aerial cable, which for a considerable number of lines is practically a physical necessity, in any event.

FIG. 3.—EXAMPLE OF JOINT CONSTRUCTION POLE LINES—UNDERGROUND CONNECTION.

The presence of two sets of telephone-distributing systems is a deplorable condition from every standpoint, and joint construction of the three companies involved in such situations is not practical under existing conditions, though entirely feasible from a construction standpoint. Conditions can be somewhat improved by the encouragement of one of the telephone companies to operate jointly with the lighting company.

Single-Phase Electric Motive Power on the Erie Railroad—Rochester Division—*Continued*

W. N. SMITH

ELECTRICAL EQUIPMENT.

The electrical equipment of the cars consists of four No. 132-A Westinghouse single-phase railway motors with a nominal rating of 100-h. p. each, the gear ratio being 20:63. The suspension is of the nose type and solid gears are pressed upon the axles.

FOUR-CAR ELECTRIC TRAIN AT AVON, N. Y.

The control system is of the Westinghouse electro-pneumatic type and includes three distinct circuits; the high potential, the low potential and the control circuit.

The high-potential circuit includes the pantagraph trolley, line switch and transformer. The pantagraph trolley mechanism is operated by a pair of springs and by an air cylinder. The trolley is raised and held against the wire by means of springs against its own weight, and it is lowered by the application of air pressure to pistons working in cylinders that form part of its base. When down, it is automatically locked, and the latch of this lock can only be withdrawn by applying air pressure to another small piston which then unlocks the pantagraph, allowing the springs to raise it. This trolley mechanism is so connected with the control-circuit through the line relay that any interruption in the supply of high-tension current immediately causes the trolley to be lowered by applying the air to the main cylinders in the trolley base.

The line switch is equivalent to a main high-tension breaker. It is opened and closed by air pressure, admitted by electrically operated valves. In case the supply of air is exhausted, as when the car has stood for some time unused, the line switch must first be held in mechanically by means of a handle provided for the purpose until the air pump, which can then be thrown into operation, has compressed air to about 50 lbs. pressure, which is enough to properly actuate the control system. To raise the trolley when there is no air pressure, there is provided a small automobile tire pump placed underneath one of the car seats, which is connected by a three-way cock into the trolley air piping system and enables the air-operated trolley latch to be withdrawn and power obtained that will start the air compressor and also the motor generator set which is used for charging the storage battery and supplying current to the control-circuit.

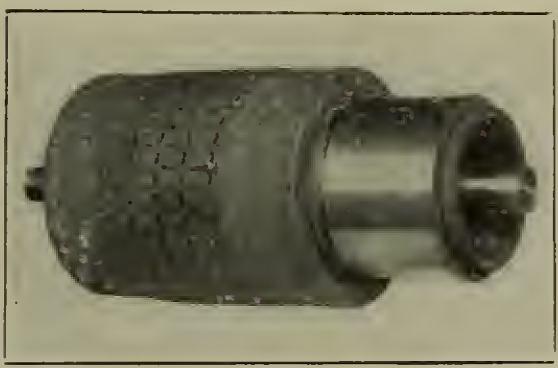
132-A WESTINGHOUSE SINGLE-PHASE RAILWAY MOTOR, 100 H.P.

The transformer is of 200-kw. capacity, and is of the oil-insulated type. It has three high-potential and eight low-potential taps, the latter running from 300 down to 110 volts, at which lowest pressure current is provided for heating, lighting and auxiliary purposes.

The high-tension wiring of the car is done mainly with varnished cambric cable, drawn through loricated iron conduit. A small amount of high-grade rubber cable is used, but it is thoroughly protected with varnished cambric tape wherever there is danger of a brush discharge to ground breaking down the insulation.

In the main low-potential circuit are the switch group, the preventive coils and the reverser. The switch group is a set of air-operated switches controlled by magnet valves, all mounted in one frame. It is placed athwart the car as near as possible to the low-tension end of the main transformer. The switches of the group are all provided with interlocks, which automatically govern the connections in such a way that each switch of the group acts only when the current in the motors has reached a predetermined value, thus making acceleration automatic. Preventive coils are used across the terminals of some of the switches of the group, to prevent excessive current flowing at the instant of closing the switch. Each switch in the group is fitted with its own blow-out coil. There are two reverser switches actuated by air pressure, one for each pair of motors.

Current from the main motor circuit is led through the motor limit switch, which makes effective the functions of the interlocks on the switch group and renders it impossible for the successive switches to be thrown in unless the limit switch is closed.



ARMATURE 100 H.P. SINGLE-PHASE WESTINGHOUSE MOTOR.

The control-circuit includes a master-controller in each vestibule, the train-line wires and their connections to the valve magnets and interlocks, a storage battery supplying current for these wires, and a motor generator set, which is used either to charge the batteries or to actuate the control system. The master-controller makes the proper connections by means of which the 15-volt storage battery actuates the valve magnets which control the action of the air-operated main contactors in the switch group and the reversers. The controller-handle is normally held in a vertical central position by springs unless it is moved to one of the running points by the motorman. When released from the grasp of the hand it flies to the vertical position, cutting off the power, and enabling the emergency application of the brakes by means of the brake-relay valve alongside of it. There are two holes in the face of the master-controller directly under the handle, and attached to the handle by means of a chain is a plug which may be inserted into either of these holes. The master-controller is not operative unless this plug is pushed all the way into the lower hole, which closes the line switch, connects the generator and battery, and puts the brake-relay valve into circuit. This is the ordinary running position of the plug. In case the line switch is opened by an overload, which generally causes the trolley to be lowered, the plug is taken out of the lower hole and placed in the upper, which action immediately closes the line switch, releases the trolley, and allows it to spring up against the wire. As soon as the power is thereby returned to the main circuit, the plug is taken out of the upper hole and replaced in the lower one.

There is a push-button upon each side of the bottom of the master-controller case. That on the right-hand side is used for dropping the trolley and opening the line switch. When the button on the left-hand side is pressed, the switch-group is stepped up to the last or high-speed notch and remains in that position until the handle of the controller has been returned to the off-position.

There are four different notches on each side of the controller, the first corresponding to the coasting position with the power off, the others enabling such gradations of speed as may be desired. Reversal is effected by moving the controller-handle to the opposite side of the center or dead point. If the controller stops on the dead point, as it will if released by the hand, it will immediately apply the brakes.

The motor-generator set is a compact machine of about $^{1}/_{6}$-kw., the motor being of the self-starting induction type, wound for 110 volts, the generator being normally of about 23 volts. It is placed under one of the seats in the car and is covered by a box with removable lid, so that it can easily be reached for such small attention as it requires. It is mounted upon rubber bushings and runs so quietly that its presence in the car can hardly be detected.

all the switches and fuses for the control of the battery and motor generator set, the lighting circuits and heaters, and also the main connection from the low-tension side of the transformer to the auxiliaries.

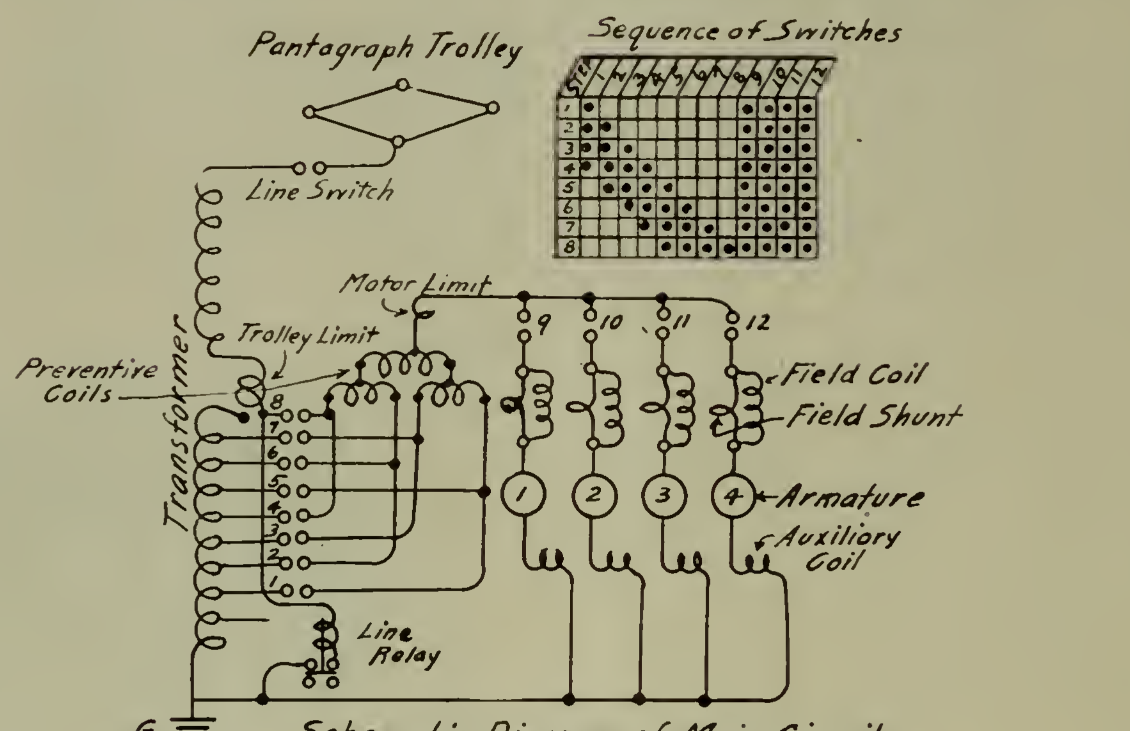
The control-circuit is fitted with junction boxes, branches running to receptacles at each of the four corners of the car directly under the end sills. The jumpers for connecting the cars and the receptacles are of the 12-point type, there being 12 wires in the main control-circuit.

The low-tension wiring between the transformer and switch-group, and motors, is all enclosed in a boxing of "Transite," to insure its protection against mechanical injury, as the inductive effect of heavy currents at low potentials renders the use of iron conduits impossible for this part of the wiring.

The air-brake and electrical equipment were placed upon the cars by the engineers at the Buffalo car shops of the Erie Railroad.

ORGANIZATION.

The single-phase system was recommended for the electrification of this division by the Electric Traction Commission of the Erie Railroad and, after authorization by the company, was installed under the general direction of Mr. J. M. Graham, Vice-President and head of the construction department of the Erie.



Schematic Diagram of Main Circuits
4 Motor Car Equipment

The storage battery consists of seven cells contained in a wooden box with handles, carried in an enclosed box underneath the car. No other auxiliary lines for any purpose are connected to the control-circuit, in order to prevent it from being disabled by accidental grounds.

In one vestibule there is located in an asbestos-lined compartment enclosed with steel doors a slate switchboard panel upon which are carried

The engineering and the construction work were carried out and the system brought into operative condition by Westinghouse, Church, Kerr & Co., who designed and erected the buildings and the catenary trolley construction, bonded the track and installed the electrical apparatus in the substation and on the cars.

Thomson High Torque Induction Test Meter, Type IB-2

To every central station or isolated plant the question of periodical meter calibration is of vital importance, and the customary method of making such tests is by the use of indicating instruments. Although there is no question regarding the accuracy of this method, the rapid

CASE WITH COVER REMOVED SHOWING CORD AND SWITCH FOR CONTROLLING THE METER.

growth of electric lighting and power systems and the more than proportionate increase in the use of rotating meters, demand that some way be provided whereby tests may be made more quickly, and yet without decreasing their reliability in the least. Such a method is provided by the Thomson high torque induction test meter.

In using this meter it is unnecessary that the load shall be constant, as the only observations necessary are the number of disk revolutions of the meter undergoing test and the pointer indications of the standard meter before and after test. Both meters integrate the instantaneous values and hence it is unnecessary to obtain the mean value or require an unvarying load. The time saved by this device will be appreciated when it is remembered that no check tests have to be made, nor need a reading, once commenced, be discontinued on account of load fluctuations.

Furthermore, the meter is so designed that one standard may be used for testing meters of different capacities covering a range from light load to full load. This further renders possible more rapid testing as no time is consumed in changing standards.

Personal errors of observations are also practically eliminated as all readings may be made with precision.

The stop watch may be confined solely to the testing room or laboratory, as it is not required except in checking the test meter with the primary standards.

The test meter is enclosed in a wooden carrying case provided with a substantial strap to aid in transportation. The case is made from quarter-sawed oak with antique finish. It is of a convenient size, being only 9.5 in. by 8 in. by 7 in. in over-all dimensions.

The cover is provided with lock and key for the prevention of tampering by unauthorized persons.

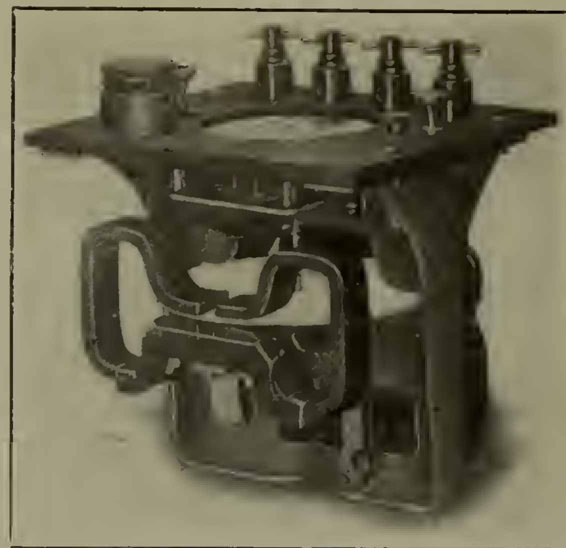
The register of the meter is very large and easily read and is placed on top. This feature is particularly advantageous when making tests at points of installation where there is no opportunity to hang up the meter, but where it must be placed on the floor or some other place below the observer. The register is of the three pointer type. The largest pointer reads directly in disk revolutions, and as the dial is subdivided into 100 equal parts, the position of the pointer may be read to hundredths of a revolution. The two smaller pointers make one revolution for each 10 or 100 revolutions respectively. It is, therefore, a very simple matter to ascertain the number of revolutions made by the disk by simply noting the position of the three pointers at the beginning and end of each test. As the full-load speed of the meter is less than 35 rev. per min., a three-minute test at this load may be made before the indications repeat themselves.

Connections to the test meter are made by means of binding posts, conveniently located on top.

At the left of the dial is placed a plug receptacle in series with the potential circuit. In this receptacle a plug is inserted and connected by means of a lamp cord to a pendant snap switch, the opening and closing of which stops or starts the meter. The cord is of sufficient length to permit of the test meter being placed at some distance from the operator.

A little to the right of the dial is placed a nurled thumb nut, by aid of which the moving element may be raised from its jewel bearing and securely locked during transportation.

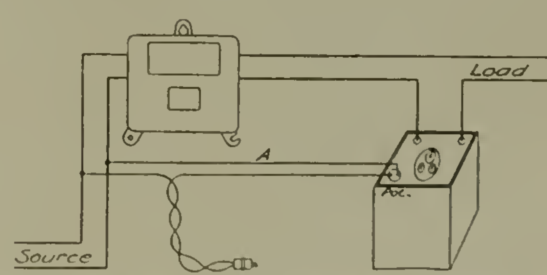
A fuse plug located at the left of the dial is in series with the one ampere winding. This protects the fine wire winding in case it should be subjected to an accidental overload. The fuse plug is of the enclosed type, thus preventing the melted fuse wire from injuring the meter.



MECHANISM OF THOMSON HIGH TORQUE INDUCTION TEST METER, TYPE IB-2.

A meter with the highest possible accuracy, both initially and throughout its entire period of usefulness, requires an indestructible bearing, and to this end the cup diamond has been adopted for the lower thrust bearing. The grinding of diamonds in a concave form has been so perfected by the General Electric Company that they are quite the equal of any other jewel bearing both in form and finish. The extreme hardness of the diamond renders it practically indestructible, and therefore of inestimable value in a meter with a rotating element.

The pivot is identical with that used for the ordinary sapphire bearing, consisting of a small piece of piano



NOTE.—Wire marked "A" must be connected to source side of meter.

TYPE IB-2 PORTABLE TEST METER, CONNECTED TO CHECK TYPE I INDUCTION METER, 2 WIRE 3/25 AMPERE.

wire, glass-hardened and highly polished, inserted in a removable brass shaft end.

The entire meter may be lifted from the case by two buttons on opposite sides, thus making it easily accessible for calibration. When removed from the case, the meter will remain without support in an upright position resting upon the magnet core and central casting, to which all parts are fastened.

The potential winding is suitable for use on voltages ranging 10 per cent. on either side of the normal. Three current coils are employed, one end of each being connected to a common binding post, and the other ends terminating in each of the three remaining binding posts, which are properly marked for the various ampere capacities of the coils attached thereto. The capacities selected as being the most generally desirable are one, 10 and 20 amperes, which are sufficient for testing meters from three to 25 amperes normal capacity. The ampere turns of the three windings are equal, hence the torque is constant when the meter is operating under the same percentage of full load for the individual coils. In other words, when using the smallest winding with one ampere passing, the torque is equal to that produced by the largest coil with a current of 20 amperes. Thus, friction is entirely negligible and accuracy is obtained throughout the range. This feature will be found of the greatest importance when testing a meter on light loads, for no corrections will have to be made for possible errors in the test meter.

Curtis Steam Turbines—Horizontal Shaft Type

THE characteristics of the Curtis steam turbine as developed by the General Electric Company specially adapt it for driving horizontal shaft generators.

The shaft is very short, of small diameter, and has a comparatively low surface speed in the bearings, resulting, with the light weight of the revolving parts, in low bearing friction and small tendency to wear.

These advantageous features characterize the line of horizontal shaft Curtis turbine sets built in sizes of 20 kw., 35 kw., 75 kw., 100 kw., 125 kw., 150 kw. and 300 kw. for direct current, and 100 kw. and 300 kw. for alternating current.

They can be arranged to operate either non-condensing or condensing, and at any steam pressure above 80 lbs. for the smaller sizes and 100 lbs. for the larger. The use of superheated steam in the Curtis turbine results in greater steam economy, as in any type of reciprocating engine or turbine, but without the usual attendant difficulties from lubrication and warping of parts.

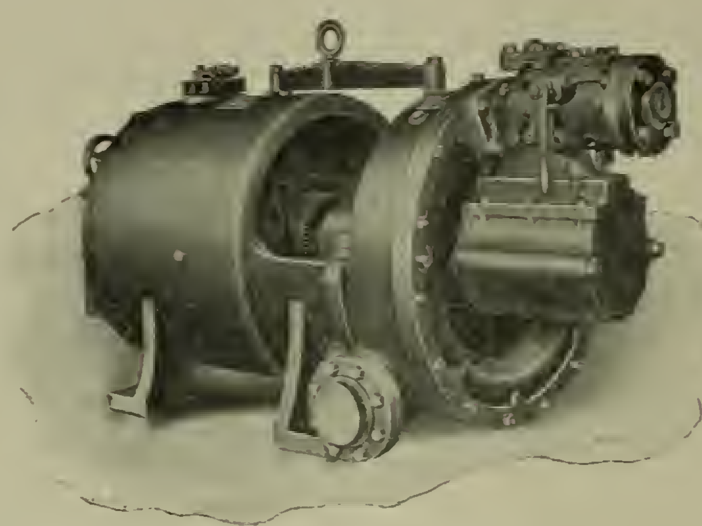
These sets require minimum attendance and may be advantageously installed for supplying light and power in mills, machine shops, laundries, apartment houses; for heating and lighting plants on steam vessels, in office buildings, railroad stations, and for train lighting. They are also extensively used for exciting alternating-current generators in central-power stations.

These machines are built either with a single-piece shaft and two bearings, or with a two-piece shaft and four bearings. In the latter type the turbine shaft is connected to the generator shaft by means of a flexible coupling. In both designs the turbine and generator are mounted on a common base. All parts of the turbine and generator are interchangeable and easy of access.

The governing mechanism is simple and reliable, controlling the speed perfectly under conditions of fluctuating load and varying steam pressure.

For condensing operation the packing is so designed that air leakage is prevented, thus eliminating the difficulties of maintaining a high vacuum, which can be used to great advantage as the turbine has a large exhaust passage and no exhaust valves. Turbines built for condensing service can be operated non-condensing in case of necessity.

The generators are of the most improved type and embody many new features, such as commutating poles and special commutator construction, particularly adapting them to continuous operation with little attention. The commutating pole construction eliminates sparking under all conditions of load.



35-KW. TURBINE WITH DIRECT-CURRENT GENERATOR.

The generators for direct current are built for 125 and 250 volts; the generators for alternating current are built for any of the standard voltages used in this class of service.

Cleanliness has been especially considered in designing these machines, and surfaces which may require cleaning are either painted or covered with planished iron. The oiling system is enclosed, is automatic, and there is no oil throwing.

The exhaust steam from the turbine is free from oil as no internal lubrication is necessary. Where the exhaust steam is used for heating or for manufacturing processes, or where condensed steam is returned to the boilers, this is of vital importance. This feature is of especial value in connection with laundering, dye works, bleacheries and paper mills.

One of the most important advantages of these turbines is the great smoothness of operation which is almost essential in buildings where noise is objectionable, and on trains and boats.

Should the turbine be flooded with water there can be no danger of stripping the buckets nor other damage. Steam is admitted in a steady flow and there is no risk of steam hammer. These turbines can be started up promptly from a cold condition without danger from accumulations of condensed steam.

Portable Standard Integrating Wattmeter for Testing Alternating-Current Service Integrating Meters

M. B. CHASE and H. W. YOUNG

THE increasing demand for a reliable, rapid and inexpensive scheme for testing service meters has resulted in the development of the portable standard method of test and a brief description of the standard, together with the applications of its use, may prove of interest to central station meter men. Briefly, this method of testing consists in comparing the disk revolutions of the service meter with the disk revolutions of a second integrating meter which has been carefully standardized at the laboratory.

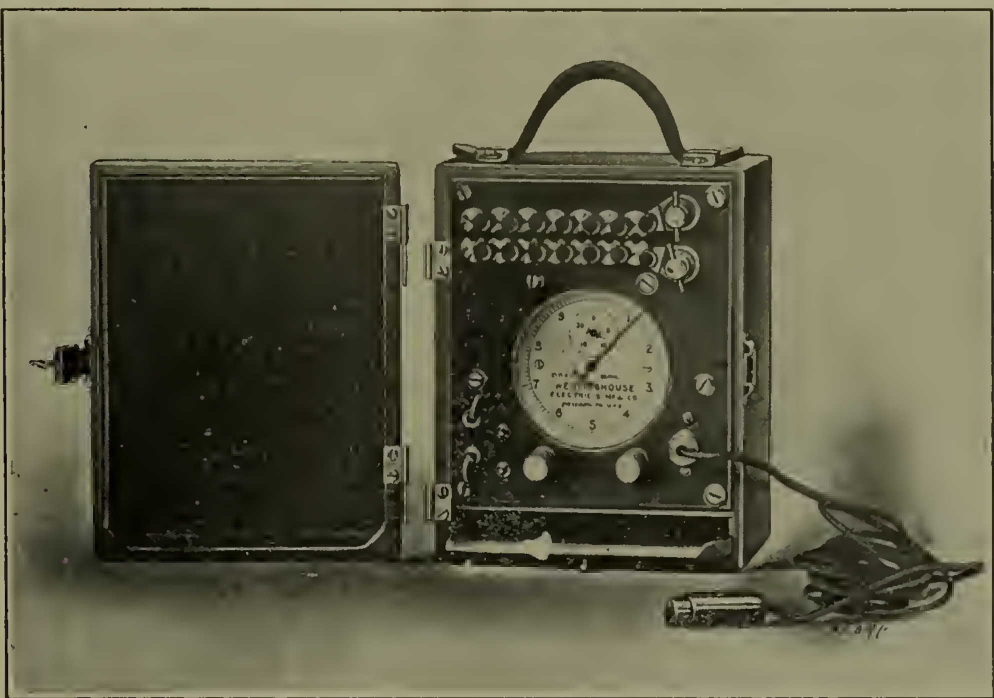


FIG. 1.—PORTABLE STANDARD INTEGRATING WATTMETER.

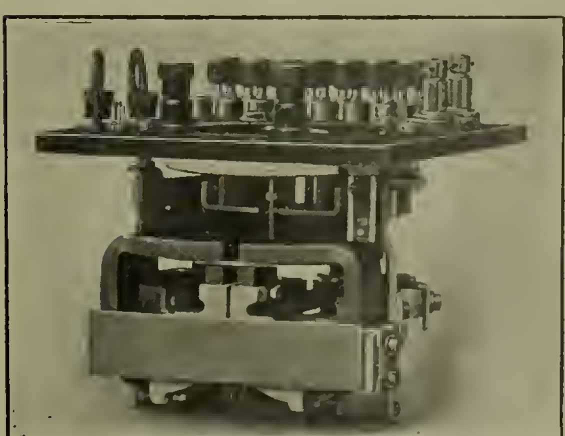


FIG. 2.—PORTABLE STANDARD INTEGRATING WATTMETER—INTERNAL VIEW.

It should be particularly noted that the method of test herein described absolutely eliminates the use of stopwatches, slide rules, calibrating formula or multipliers. For testing any make of meter it is only necessary to make direct comparisons of disk revolutions as given in the calibration table.

A form of standard which has been developed for use either as a bench or portable standard is illustrated in Fig. 1. Fig. 2 illustrates an internal view of the operating mechanism, which consists of a specially arranged set of measuring elements, the series coils of which are divided in sections and by means of a plug and connection board can be connected in series-parallel or parallel connections. The potential elements are also arranged for series-parallel connection so that by proper manipulation of the two connection plugs the meters can be used either on 100 or 200-volt circuits. The entire measuring element is secured to a polished slate base which in turn is supported in a compact carrying case.

In order to secure a construction having minimum friction, the bearing illustrated in Fig. 3 has been adopted for the portable standard meter after having been thoroughly demonstrated for some years in the regular service type of meter, and in the construction of laboratory indicating instruments. As will be seen from the illustration, the bearing consists of a steel ball located between two cupped sapphire jewels, one of which is located on a removable jewel screw and the other in a removable sleeve attached to the end of the disk shaft. By this construction a bearing is secured which has a constantly changing point of contact between the bearing surfaces, thus giving a lower friction value and in conjunction with the light moving element, a longer jewel life than can possibly be secured in meters employing the older form of bearings and heavier moving elements.

The registering mechanism also embodies features not commonly found in integrating meters in that the shafts are made of polished steel rather than of brass, and the gears and pinions are gold-plated to prevent corrosion, which is frequently present in meter registers of the usual form. Furthermore, the vertical shafts are provided with special bearings consisting of polished steel plates, so that the register not only has minimum initial friction, but the friction value will remain unchanged for long periods of service.

In order to test a service meter with the portable standard, the connections should be made as shown in Figs. 4, 5 and 6, and the connection plugs of the standard so arranged that the ampere capacity of both meters will be

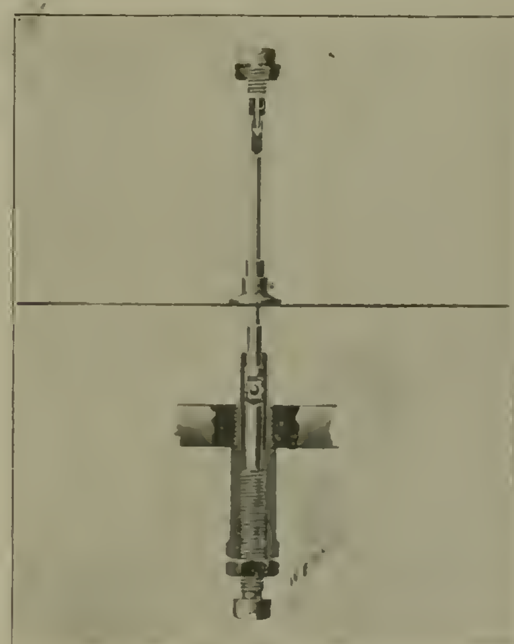


FIG. 3.—ROLLER BALL BEARING.

of approximately the same value. The load should now be adjusted to the meter only, and a direct comparison made of the number of revolutions of the meter under test with the number of revolutions indicated by the register pointers of the standard. It is good practice to continue the test for at least one minute's time in order to eliminate personal or observation errors, and the per cent. of error in the meter under test may be found directly by

Make	Service Meter Ampere Capacity	Revolutions Heavy Load	Revolutions Light Load	Standard Meter Ampere Capacity	94 Per Cent	95 Per Cent	96 Per Cent	97 Per Cent	98 Per Cent	99 Per Cent	100 Per Cent	101 Per Cent	102 Per Cent	103 Per Cent	104 Per Cent	105 Per Cent	106 Per Cent
					Revolutions of Westinghouse Portable Integrating Wattmeter For 94 Per Cent to 106 Per Cent Registration of Service Meter												
*Westinghouse types B and C	5 10 20 40	25 25 25 25	... ...	5 10 20 40	26.5	26.25	26.00	25.75	25.5	25.25	25	24.75	24.50	24.25	24.00	23.75	23.50
	5 10 20 40	. . .. ..	1.0 1.0 1.0 1.0	5 10 20 40	1.06	1.05	1.04	1.03	1.02	1.01	1.	.99	98	97	96	95	94
General Electric Type I	80 80	15 .	. 1.0	40 40	31.8 2.12	31.5 2.1	31.2 2.08	30.9 2.06	30.6 2.04	30.3 2.02	30. 2.	29.7 1.98	29.4 1.96	29.1 1.94	28.8 1.92	28.5 1.90	28.2 1.88
	3 3	30 	. 2.0	5 5	19.08 1.27	18.90 1.26	18.72 1.25	18.54 1.23	18.36 1.22	18.18 1.21	18. 1.2	17.82 1.19	17.61 1.18	17.46 1.16	17.28 1.15	17.10 1.14	16.92 1.13
	5 10	30 30	..	5 10	28.62	28.35	28.08	27.81	27.54	27.27	27	26.73	26.46	26.19	25.92	25.65	25.38
	5 10	. .	2.0 2.0	5 10	1.91	1.89	1.87	1.85	1.84	1.81	1.8	1.78	1.76	1.75	1.73	1.71	1.69
	15 15	30 .	.. 2.0	20 20	23.85 1.59	23.62 1.57	23.4 1.56	23.17 1.54	22.95 1.53	22.72 1.51	22.5 1.5	22.27 1.48	21.83 1.47	21.6 1.45	21.38 1.44	21.15 1.42	20.93 1.41
	25 50	30 30	... ...	20 40	35.72	35.38	35.05	34.71	34.37	34.04	33.7	33.36	33.03	32.69	32.35	32.02	31.68
	25 50		2.0 2.0	20 40	2.38	2.36	2.34	2.32	2.29	2.27	2.25	2.23	2.2	2.18	2.15	2.13	2.11
Fort Wayne Type K	5 10 40	30 30 30	.. ... .	5 10 40	23.85	23.62	23.4	23.17	22.95	22.72	22.5	22.27	22.05	21.82	21.6	21.37	21.15
	5 10 40	.. ..	2.0 2.0 2.0	5 10 40	1.59	1.57	1.56	1.54	1.53	1.51	1.5	1.48	1.47	1.45	1.44	1.42	1.41
	25 50	30 30	.. ...	20 40	23.85	23.62	23.4	23.17	22.95	22.72	22.5	22.27	22.05	21.82	21.6	21.37	21.15
	25 50	. ..	2.0 2.0	20 40	1.59	1.57	1.56	1.54	1.53	1.51	1.5	1.48	1.47	1.45	1.44	1.42	1.41

It is recommended that test be made at approximately 100 per cent and 4 per cent of full load if these loads are within the range of standard meter.

Load service meter so as to give revolutions stated in table in approximately one minute time.

Where possible, the capacity of coils used should be the same for both service and standard meters.

*Westinghouse Round Pattern and type "A" meters make fifty revolutions per minute at full load.

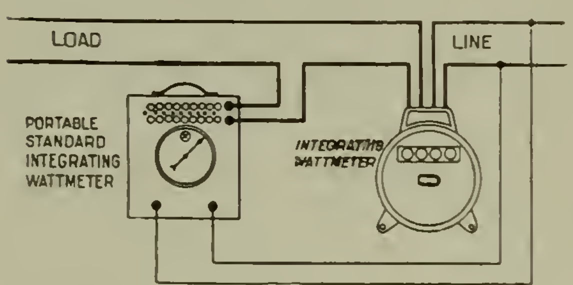


FIG. 4.—CONNECTIONS FOR CHECKING SELF-CONTAINED SERVICE SINGLE-PHASE METER.

dividing the number of revolutions of the standard by the number of disk revolutions made by the service meter.

The standard described above was primarily designed for testing meters which run at the same full-load speed: namely, 25 rev. per min., but in order that it may conveniently be used in testing meters in which the full-load speed has a different value, a table has been prepared as applying to Westinghouse, General Electric and Fort Wayne meters. By the use of this table any one of the three makes can easily be tested with the one standard.

In explanation of the use of this table, the following examples are given:

(1) If it is desired to test a Westinghouse service meter by using the portable standard, the two meters should be connected in series and loaded so as to give one revolution of the disk in approximately one minute's time for a light-load test and for full load twenty-five revolutions of the disk in the same time. The number of revolutions made for these two loads by the standard—if the service meter is correct—would be one and 25 respectively. If the number of revolutions made by the standard is 1.03, the service meter is three per cent. slow at light load. If the number of revolutions of the standard is 0.97, the service meter is three per cent. fast at light load. From this example it will be seen that the accuracy can be determined for any speed within six per cent. fast or slow, reading same directly from the table without any calculation whatever.

(2) If it is desired to test a five-ampere General Electric meter, the load can be adjusted to give, say, two revolutions at light load and 30 revolutions of the disk at heavy load in approximately one minute's time. If the meter is correct, the standard will show 1.8 and 27 revolutions respectively. If the standard shows 1.85, the service meter is three per cent. slow at light load. If the standard shows 1.75, the service meter is three per cent. fast at light load.

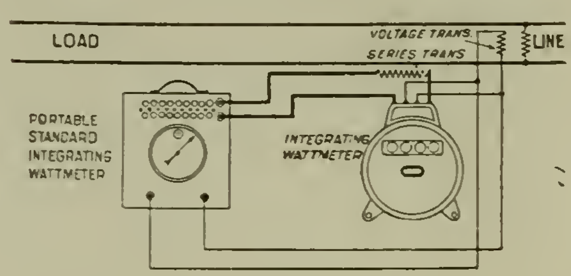


FIG. 5.—CONNECTIONS FOR CHECKING SINGLE-PHASE SERVICE METER EMPLOYING SERIES AND VOLTAGE TRANSFORMERS.

(3) If it is desired to test a five-ampere Fort Wayne meter, the load can be adjusted to the same value as with the General Electric meter. If the meter is correct, the standard will show 1.5 and 22.5 revolutions respectively. If the standard shows 1.54, the service meter is three per cent. slow at light load. If the standard shows 1.45, the service meter is three per cent. fast at light load.

If it is desired to test three-wire meters, the standard should be connected into the circuit with one side of the meter under test, the other side of the circuit being left open. When the test is conducted in this manner, the portable standard pointer will revolve at a rate twice as fast as the disk of the meter under test, which has but one-half of its current winding in use during the test. To effect a direct comparison, the number of revolutions made by the meter being tested should be multiplied by two.

As the polyphase meter is practically two single-phase meters having a common shaft and registering mechanism, it can be attached and tested as a single-phase device and the portable meter used as a standard. In testing polyphase meters it is customary to remove the meter from service and employ an artificial load, testing each side as a single-phase element. To test a self-contained polyphase

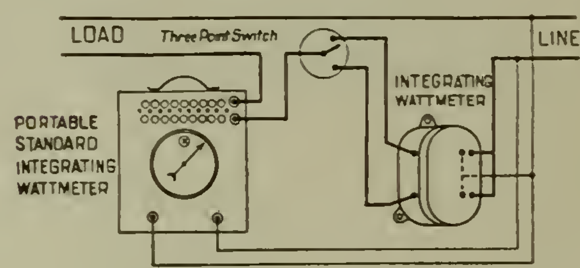


FIG. 6.—CONNECTIONS FOR CHECKING POLYPHASE SERVICE METER BY MEANS OF SINGLE-PHASE STANDARD.

meter using neither series nor voltage transformers, a connection should be made as shown in Fig. 6. A three-point switch is provided to cut either series element of the service meter in circuit with the standard. As but one side of the meter is in service at the same time, it is customary to multiply the disk revolutions by two, thus permitting of a direct comparison with the portable standard, the disk of which would run at twice the speed of the single element of the polyphase meter.

In all tests of polyphase meters, both potential elements must be connected in circuit and energized, otherwise errors of greater or less magnitude will be introduced. If desired, the current elements of the polyphase meter may be connected in series with each other when making test, thus operating both elements together and giving a full-load speed of the service meter equal to that of the standard.

Electric Locomotive—*Continued*

H. L. KIRKER

V. MOTOR-COMMUTATION.

We have just seen that we can give the wire a reciprocating motion across the magnetic field by simply reversing the current in the wire. Now, if the reciprocating motion of the steam-engine piston can produce rotary motion, why, we should be able to transform the reciprocating motion of a

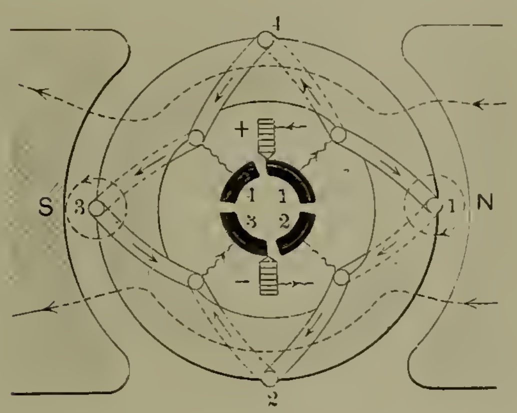


FIG. 18.

wire across the magnetic field into rotary motion also.

Suppose we introduce a pivoted iron ring into the air gap. It becomes a portion of the path, and you will note that none of the lines pass through the internal air gap. Let us imbed our wire in the surface of the ring and send a current through the wire. The wire, as we have just seen, moves across and out of the field, but in doing so it imparts a turning motion to the ring. The momentum of this ring carries the wire on over into the field again. Now, if we reverse the current, the wire is thrust across and out of the field once more. If we reverse the current again after the momentum of the ring has carried the wire into the field once more we keep up the rotary motion in a continuous direction. See Fig. 17.

There need be no guess as to which way the ring will rotate. All we have to do is let our magnetic field whirl clock-wise and let the armature current run from front to rear under the north pole. The direction of the main vortex is clock-wise and the axis of this vortex is the axis of the main ring. The direction of the vortex around the armature wire is clock-wise also, consequently, the wire moves in toward the axis of the main ring. This motion of the wire imparts a counter clock rotary motion to the ring.

During the time the momentum is carrying the wire over under the south pole we reverse the current. The direction of the eddy around the armature wire is now counter to the main, consequently, the wire is now forced down and out of the magnetic field. Reversing the current again as the momentum carries the wire under the north pole we see that the wire is forced up across the north pole again, and so on. The result is continuous rotation in a counter-clock direction so long as the direction of the armature current is from front to rear under the north pole and from rear to front under the south pole.

Now that we know we can produce continuous rotation of the pivoted ring in the magnetic field by reversing the current as the wire passes from pole to pole, our next concern is the means for reversing the current. Well, as the piston of a steam engine reaches the end of the stroke the valve gear admits steam on the opposite side of the piston. It is the motion of the engine that operates the valve gear. Likewise, the rotation of the motor armature can be made to commutate the current in the wire as the wire passes from pole to pole. A toy motor commutates in the same way as the commercial article. Now mechanical toys are always interesting, so I will call your attention to a diagram of a toy machine. See Fig. 18.

We have put four coils on the ring, spaced them uniformly and connected the end of each coil to the beginning of the adjacent coil to the right. This gives us a closed spiral since the end of No. 1 is connected to the beginning of No. 2, the end of No. 2 to the beginning of No. 3, No. 3 to No. 4 and No. 4 to No. 1. Now note the tap from each one of the front cross connections to a corresponding insulated

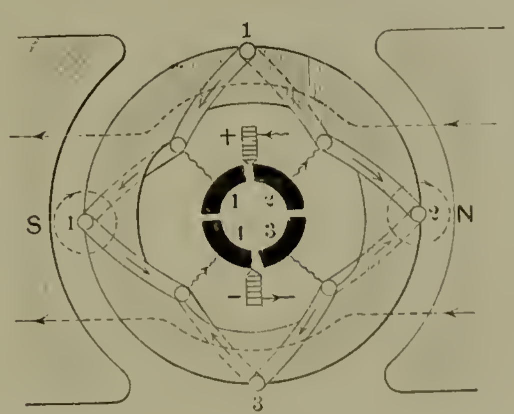


FIG. 19.

quadrant of a metal bush fixed on the armature shaft. You see we have also added two insulated copper brushes and placed them diametrically opposite each other in the vertical plane and in contact with the four-segmented bush which we will call the commutator.

When segment No. 1 is under the top brush, No. 3 is under the bottom. As the armature rotates counter clockwise, No. 2 comes under the top brush and No. 4 under the bottom, then No.

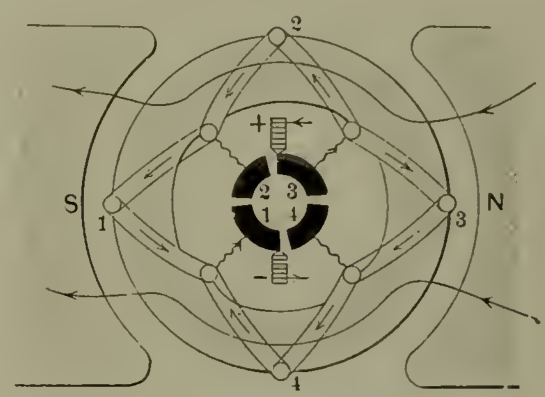


FIG. 20.

3 under the top and No. 1 under the bottom, then No. 4 under the top brush and No. 2 under the bottom and so on. Now let us connect the top brush with the positive brush of a dynamo and the bottom with the negative and trace the current down through the motor armature winding. If the electric current can find its way through that armature winding we can surely follow its trail.

Starting with the segment that taps the cross connection between coils No. 4 and No. 1, we see that there are two paths and that half the current runs down through the two coils, No. 1 and No. 2, on the right-hand half of the armature and that the direction of this current is from front to rear in both wires on the surface under the north pole—just as we wanted it. See Fig. 18. The other half flows down through the coils, No. 4 and No. 3, on the left hand half of the armature, and the direction of the current in the wires on the surface of the armature under the south pole is from rear to front, also as we wanted it. The two currents meet in the cross connection between No. 2 and No. 3, and pass out through the tap to segment No. 3, thence into the brush which is connected to the negative brush of the dynamo. We see, then, that as the direction of the current in the wires on the surface of the armature under the north pole is from front to rear, that these wires will be pushed up, and that as the direction of the current in the wires on the surface of the armature under the south pole is from rear to front, that these wires will be pushed down. As there are practically no lines in the air space within the armature ring, no force is exerted on the internal wires. The push on the outside wires starts the armature to rotate in a counter clock-wise direction.

By the time coils No. 1 and No. 3 are in a vertical position, bar No. 1 is no longer under the positive brush, and No. 3 no longer under the negative, but bar No. 2 now makes contact above and No. 4 below. See Fig. 19. If we trace the current again we see that it now enters the armature winding through the top to the cross connection between coils No. 2 and No. 1, and that it travels down the right-hand half of the armature ring through coils No. 2 and No. 3 and down the left-hand half through coils No. 1 and No. 4. The direction of the current in the wires under the north pole is as before, from front to rear, and under the south pole from rear to front. Rotation continues in the counter clock-wise direction.

Another quarter turn brings coils No. 2 and No. 4 into the vertical plane and puts the commutator bar No. 3 under the top brush and No. 1 under the bottom and the current now passes down the right-hand half of the armature through coils No. 3 and No. 4, and down the left-hand half through No. 2 and No. 1, and is always from front to rear under the north pole and from rear to front under the south pole. See Fig. 20. Counter clockwise rotation continues. Another quarter turn and the armature has made a complete revolution. We could continue to trace the current through the windings, but it would only be a repetition of what we saw before, namely, that the direction of the current in the wires under the north pole is always from front to rear, and under the south pole from rear to front. The description is rather long, but the facts are simple enough. They are easily followed with the aid of a diagram. But it is worth the trouble. A few minutes' serious attention will put this commonplace thing—the continuous rotation of the motor armature—within the grasp of anyone who really wants to understand it. The commutator, then, is the means of changing the direction of the current in the armature wires, as they pass from pole to pole.

The movement of the wires across the magnetic field is nothing more than the tendency of parallel wires to pull together when they are carrying currents of the same direction, and the tendency to push apart when they are carrying currents of the opposite direction; for as I have pointed out, the magnetic field can be considered as a portion of a powerful vortex whose axis is the axis of the main ring, and whose direction of rotation is constantly clock-wise, and the armature wire can be considered as the axis of a second vortex whose direction of rotation is alternately clockwise and counter clock-wise. Consequently, when the two vortexes are clock-wise, the armature wire moves in toward the main axis, and when the armature vortex is counter clockwise the armature wire moves away from the main axis, and as the location of the brushes is such that the current is reversed in each wire as it finishes its travel across the field, and as the wires are imbedded in a pivoted ring, continuous rotation of the pivoted ring must ensue.

(*To be continued.*)

Electric Motor Connections

CONNECTIONS for the repulsion induction single-phase self-starting motors made by the Century Electric Company, of St. Louis, are illustrated by Figs. 1 and 2. These motors are interchangeable for 104 or 208 volts by making the slight change of connectors on the terminal board indicated in Fig. 2. The terminal board is located inside the motor on the commutator end directly underneath the line terminals.

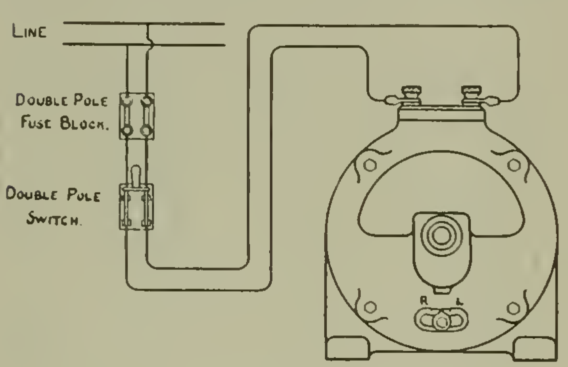


FIG. 1.

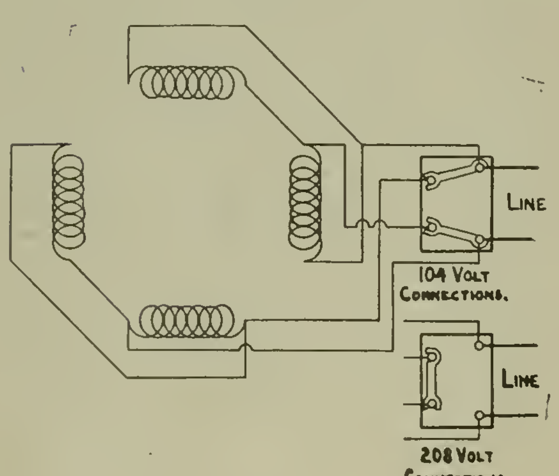
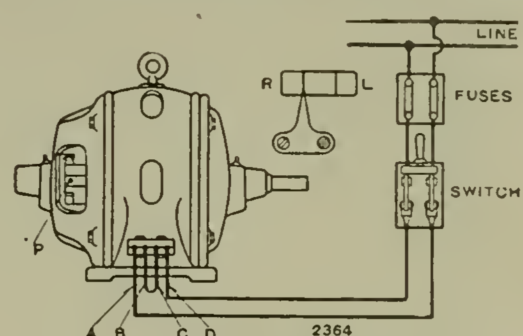
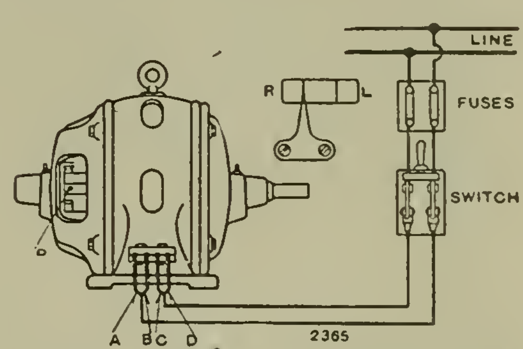


FIG. 2.



FOR 208 VOLTS CONNECT "B" AND "C" TOGETHER AND "A" AND "D" TO LINE.

FIG. 3.



FOR 104 VOLTS CONNECT "A" AND "B" TO ONE LINE AND "C" AND "D" TO THE OTHER.

FIG. 4.

The motor starts as a repulsion motor, but on reaching full speed the governor weights are thrown out, due to centrifugal force short-circuiting every commutator bar to one common ring of high conductivity and at the same time releasing the tension on the carbon brushes and pushing them back away from the commutator, allowing the motor to run as an induction motor. The governor is entirely automatic, and when the motor is stopped the device returns to its original starting position. The commutator is in service only during the period of starting, ranging from five to 20 sec., depending upon the amount of load to be brought up to speed.

In Figs. 3 and 4 are shown the connections to single-phase self-starting motors, made by the Wagner Electric Manufacturing Company, St. Louis; the difference in these figures consisting of the modification in connections required for full and half line voltage.

As sent out, the brush holder is set for clockwise rotation looking at the commutator end. If it is desired to run in the opposite direction, screws P are loosened and the brush-holder turned until the mark L on the index plate stands opposite the pointer.

SELLING CURRENT

The History of Electric War in Toledo

C. N. JACKSON

Formerly Commercial Manager of the Toledo Gas, Electric and Heating Company

THE Toledo Railways and Light Company controlled the electric light business in Toledo up to the year 1905. The Toledo Heating and Lighting Company was a small corporation formed for the purpose of heating and lighting residences in the best residence section. The two companies got along very well together for several years, in fact, neither one wanted to start trouble, so the smaller company kept in its own territory, and the big company, whenever it did any business in that section, maintained its regular rate of 13.3 cents per kilowatt-hour for residence lighting for fear the little one would get mad and extend its lines into the business district and cause a war.

During the spring of 1905 certain local capitalists thought it would be a good plan to buy the Toledo Heating and Lighting Company and Toledo Gas Light and Coke Company, merge the two, and make war on the Toledo Railways and Light Company, and in time force the Toledo Railways and Light Company to buy them out. They quietly secured options on the majority of stock of the two companies and then organized the Toledo Gas, Electric and Heating Company, which purchased the Toledo Heating and Lighting Company from the promoters, paying them in bonds and stock of the Toledo Gas, Electric and Heating Company. The bonds amounted to nearly double the cash originally paid out by the promoters, and, besides, they got nearly a million in common stock. The Toledo Gas, Light and Coke Company stock was turned in by the stockholders, who received bonds of the new company, and 50 per cent. stock in exchange.

The capitalists then laid their plans to wage war on the Toledo Railways and Light Company and force it to buy them out. Knowing that I was acquainted with the local conditions, having had charge of the Toledo Railways and Light Company contracting department for three and one-half years and had lately severed my connection with it, they sent for me and asked me if I could "Hang the Toledo Railways and Light Company's pelt on the wall?"

I said I could, providing they would let me have my own way and not handicap me with orders from every "Tom, Dick and Harry" connected with the organization. We finally agreed upon terms, and I went to work to lay my plan of the campaign.

Having had several years' experience as a salesman, and knowing myself and the people, I decided to go after contracts in the business section before we had put in a pound of copper. The president fought me on this point. He argued that a business man would be very foolish to tie himself up on a contract one year before the service could possibly be given, and wanted me to go out in the residence district where we had service and get new business there. I was so determined that my plan was feasible that I ordered contract forms printed, which were drawn up by our lawyer, and were iron-clad in every respect. They were good for a connection at any time within one year from date.

As soon as the contract forms came from the printer I went out to try my plan, which I had repressed until I could put a good argument on the reasons why I should get the man's contract at that time. The first place I went after was a cigar store where I was unacquainted. I took the proprietor to one side and very confidentially told him that I was representing the Toledo Gas, Electric and Heating Company, who had recently purchased the Toledo Heating and Lighting Company, and the Toledo Gas Light and Coke Company. In view of the fact that it was generally understood that the Railways and Light Company had always charged an exorbitant price for electric light, our directors had, at a recent meeting, decided to run the lines into the business district and compete with the Railways and Light Company, providing we could get sufficient business to warrant the investment. Consequently, I was making contracts with the business houses for electric lighting. Regarding the price to Mr. Blank, I said: "We will only charge cost plus a reasonable profit. Of course, the first year, when our customers are few and our organization a new one, we do not expect to do much better than the present prices of the Railways and Light Company, but we will guarantee their price at least, and later, as soon as we have been operating a few months, it is very possible that we will cut the rate; in any event, you have everything to win and nothing to lose, as any business man knows that competition guarantees the lowest possible price. Of course, Mr. Blank, you can't expect our company to spend nearly a million dollars in running the lines into the district without contracts enough to guarantee at least one year's business, after that we are willing to take our chances in a fight. Our directors would not be so foolish to run the lines and then ask for contracts, because as soon as we had commenced to run our lines the other company would only have to cut their price a trifle and tie up all the business and there would be nothing left when we were ready to serve."

By that argument I secured three contracts in the first hour, a cigar store, drug store and implement house. I was so elated at my success that I stepped into the office of the president of our company, who greeted me in this way: "Now, Jackson, there is no use of your spending your time downtown; get out in the residence section and get the business out there. No man will give you a contract in the business district when we can't promise service for several months."

I then handed him one of the contracts and asked him how he liked it—it opened his eyes, but they opened wider when I showed him the other two. He couldn't find words to express his feelings, but he did tell me to go ahead, that I certainly knew what I was doing. I immediately began to employ solicitors and train them to follow my plan, and at the same time I engaged two young men to call on every user of electricity and put all information secured on a 4 by 6-in. card.

They generally learned the name, address, class of business the user was engaged in, lamp and motor equipment, rate they were paying the Toledo Railways and Light Company and average kilowatt-hour consumption per month. When after the last item, they usually saw the bills and at the same time the rate.

(*To be continued*).

QUESTIONS AND ANSWERS

No. 1010.—*Please let me know how to measure the setting for a potential regulator when in the central station. We have one at a substation and regulate it for 2080 volts by voltmeter, but want to move it into the central station. How can the voltage at the substation be determined at the central station?* A READER.

Run pressure wires, that is small wires, from the substation back to the central station and connect them to a voltmeter. There are several devices made for compensating the voltage at the voltmeter to agree with any line drop in potential. Any of these devices may be installed and will be found cheaper than the pressure wires for long distances.

No. 1011.—*What are the good points of an incandescent lamp of poor efficiency? I always supposed price varied with the efficiency until recently when a salesman quoted the same price on 3.5-watt and 3.1-watt lamps.* F. G. H.

Lamps of poor efficiency do not have merit on account of this fact. Usually, they have a longer life than lamps of good efficiency. There is no difference in the construction of the lamp; the difference consists in the voltage at which it is rated. If the voltage is steady and current costs more than five cents per kilowatt-hour, buy the 3.1-watt lamps. If the current costs less than five cents per unit take the 3.5-watt lamps.

No. 1012.—*Are alternating-current induction motors suitable for the operation of cranes and hoists? I see them advertised, but when I ask for the actual figures the crane builders try to induce me to put in a direct-current equipment.* O. S. P.

Alternating-current induction motors are suitable for cranes and hoists, but they must be run with the conditions for which they are designed. Motors for this work having a high resistance secondary will not stand the amount of abuse that is possible with separate motors and resistances. The amount of space available for placing resistances in the motor rotor is very small, while separate resistances may be made as large as desired.

No. 1013.—*Why are shunt-wound motors never used on street cars? I should think some of the power could be returned to the trolley when the car is running downhill.* F. W.

Where the road is a straight run up a continuous grade and downgrade on the return with few stops, shunt-wound motors may be used for railway work. Usually, street cars are started so frequently that any advantage of the shunt over the series motor in returning power to the line is offset by its poorer starting torque.

No. 1014.—*Please let me know of a method by which I can light my room by electric light without buying current from the lighting company?* ECONOMICAL.

Yes, if you are satisfied with a light equivalent to a tallow candle, otherwise, no. I take it for granted that you wish to use primary cells. Use a 1.25-volt tantalum miniature lamp and a large renewable primary cell. This makes a good light for photographic work and is a good night-lamp when used only occasionally.

Review of the Technical Press

Circuit-Interrupting Devices

F. W. HARRIS.

(The Electric Journal, November, 1907, p. 606.)

Oscillograms taken by breaking the circuit on various devices show that on short-circuits the fused circuit breaker consisting of a fine wire under considerable tension and enclosed in an expulsion tube gives the best results.

Next in order of quickness comes the expulsion fuse in which wire is not under tension and in which the arc is simply ruptured in a small tube. Circuit breakers in general take about twice this time to open, as they have considerable inertia.

Practical Experience with Exhaust Steam Turbines

DR. ALFRED GRADENWITZ.

(The Engineering Magazine, November, 1907, p. 278.)

The author mentions the work of M. A. Rateau, of Paris. He then gives data on several installations.

One plant is that at the mines of Klein-Rosseln, Germany. The generator set has an output of 370 kw. The steam consumption is 17 kg. per kw. hr. The initial pressure is 1.3 kg. per sq. cent., and the final pressure 0.10 kg. per sq. cent.

Pantograph Collector for High-Speed Electric Railways

JOSEPH MAYER.

(Street Railway Journal, November 9, 1907, p. 951.)

The design illustrated and invented by the author of this article uses an aluminum bow carried by light tubular radial arms which by swinging around a shaft give the bow an adequate range of vertical motion independent of the heavy frame below.

Ratio of Generator Capacity to Motor Horse Power in Electric Drive Installations

GEORGE R. HENDERSON.

(Proceedings of the New England Railroad Club.)

At the 1903 convention of the Master Mechanics' Association, a committee reporting on electrically driven shops stated that 40 per cent. of the aggregate horse power of the tools could be taken, and to this added the constant and average lighting load in order to determine the capacity of the generators required, without including in the list of such motors those required for cranes, transfer tables or turntables; but the question of a spare unit should always receive consideration. The Master Mechanics' proceedings for 1900 stated that at the Baldwin Locomotive Works, the switchboard load averaged only about 27 per cent. of the total motor rating, in this case the crane motors being included. At the Topeka shops a switchboard load equal to 38 per cent. of the various motors, exclusive of those on the cranes, was found to obtain. At the McKee's Rocks shop the power consumption was about 30 per cent. of the motor rating. At Collinwood the total generator capacity (after deducting requirements for lights) was 50 per cent. of the sum of the motor ratings, not counting those upon the cranes. At McKee's Rocks shop it was 47 per cent. on the same basis; at the Angus shop, Montreal, 37 per cent. The new Parsons shop of the M., K. & T. Railway has a generator capacity of about 75 per cent. of the total rated motor capacity.

European vs. American Methods of Street Lighting

H. T. OWENS.

(The Illuminating Engineer, November, 1907, p. 643.)

A four-page article giving the methods of lighting streets in London and Paris.

The Demagnetizing Factors for Cylindrical Iron Rods

C. L. B. SHUDDEMAGEN.

(Proceedings of the American Academy of Arts and Sciences, September, 1907, p. 185.)

When an unmagnetized iron bar is placed in a fixed magnetic field and thereby becomes magnetized, the actual force within the iron is not so great as the original permanent magnetic force at the same point before the iron was introduced. Seventy pages are devoted to an exhaustive mathematical and experimental treatment of this subject.

The Present Status of the Producer-Gas Power Plant in the United States

ROBERT HEYWOOD FERNALD.

(Journal of the Western Society of Engineers, October, 1907, p. 551.)

The subjects gas producers, gas engines, fuel values, grades of coal, power-station economics and costs are treated in an able and exhaustive manner. The author is professor of mechanical engineering, Washington University, St. Louis, and engineer in charge of producer gas tests of the United States Geological Survey fuel-testing plant.

Most Powerful Electric Locomotive

(Electric Trunk Age, October, 1907, p. 1.)

A description of the locomotive used on the railroad through the Simplon Tunnel between Switzerland and Italy, and a comparison of this locomotive with other recent powerful engines, both electric and steam.

	Simplon Three-Phase	N. Y. Central Continuous	New Haven Single-Phase	N. Y. Central Atlantic	Erie Mallet
Weight, tons	68	95	93	161	280
Length	36′ 6″	37′ 0″	36′ 4″	62′ 3″	about 75′
Normal Horse Power	2700	2200	1000	1360	2000
Maximum Horse Power	8000	3000	2000	1500	2500
H. P. per ton weight	39.7	23.2	10.8	8.5	7.2

Shall Central Stations Do Construction Work?

F. A BERLIN.

(Electrocraft, November, 1907, p. 633.)

Next to inefficient workmen, the central station companies who do construction work are the greatest source of trouble to the electrical contractor.

The remedy, however, rests largely with the contractors. Let their various organizations work for municipal ownership of public utilities, for legislation which shall make it a penitentiary offense for any public service corporation to discriminate in rates, and see that they pay their just amount of taxes, and for the use of the streets. It is also well to show up the aldermen and other city officials who are obtaining free light for their homes and saloons.

Electricity in the Manufacture of Roofing Paper

L. B. VAN NUYS.

(Western Electrician, November 30, p. 423.)

A description of the electric plant in the factory of the Barrett Manufacturing Company in Peoria.

An Analysis of the Distribution Losses in a Large Central Station System

L. L. ELDEN.

(Proceedings of The American Institute of Electric Engineers, November, 1907, p. 1595.)

The central station system considered is typical of those throughout the country. The following table gives the losses in station apparatus.

	Kilowatt-hours	Loss in per cent. of total power generated	Loss in per cent. of input
230-volt motor-generators	5,527,416	7.42	17.6
500-volt motor generators	373,059	0.50	33 6
Series arc motor-generators	2,403,471	3 22	25 5
Step-down transformers	1,010,848	1.36	3.23
Constant-current transformers	118,548	0 16	5.40
Potential regulators	65,353	0 09	3.53
Batteries	807,067	1 09	43.2
Boosters	211,264	0 28	63 0
Balancers	67,725	0 09	
Water rheostats for testing	1,366		
Total	10,586,117	14 21	

CATALOGUE REVIEW

Frank Mossberg Company, Attleboro, Mass., has recently distributed a 41-page catalogue of wrenches, bells, advertising novelties, reels and spools, punches and dies.

The Sandusky Foundry and Machine Company, Sandusky, Ohio, send catalogue illustrating its line of single-acting triplex pumps and paper mill specialties.

Zoar storage batteries are listed in an illustrated catalogue recently distributed by the Zoar Battery Company, of Zoar, Ohio.

The Mechanical Appliance Company, of Milwaukee, Wis., builders of Watson motors and generators, send bulletin No. 60, descriptive of its machines, and bulletin No. 61, illustrating motor applications.

A circular of Christmas novelties has been received from the Manhattan Electrical Supply Co., 17 Park Place and 14 Murray Street, New York.

The Lazier Gas Engine Company, Buffalo, has recently gotten out a folder containing a bulletin descriptive of the Lazier vertical gas engines and accompanied by a set of blue prints showing the internal construction of these engines.

The Westinghouse Machine Company show storage batteries for portable use in catalogue P.

Bulletin No. 5A, dated Nov. 9, 1907, has been distributed by the engineering department of the National Electric Lamp Association. This gives full information regarding the Tantalum Regular and Tantalum Meridian lamps and units.

The Allis-Chalmers Company, of Milwaukee, will send bulletin No. 1403 on request. It is descriptive of "The Hancock Jig." Facts regarding the operation are published as secured from the performance of the first machine installed for the Arizona Copper Company.

The company will also send to any electrical engineer bulletin No. 1037, which gives the method of testing alternators as perfected by B. A. Behrend.

The Thomson high torque induction test motor is described in bulletin No. 4549, recently issued by the General Electric Company, Schenectady, N. Y.

Direct-current indicating instruments, Type D, are described in bulletin No. 4552, recently issued by the same company.

TRADE NEWS

The new power station of the Columbia Improvement Co., Seattle, Wash., will be served by a 50-ton, three-motor electric Northern traveling crane, furnished by the Northern Engineering Works, Detroit, Mich.

The United Engineering & Foundry Co., Pittsburg plant, have recently installed a 10-ton, 60-ft. span electric Northern traveling crane.

The Rail Joint Company, of New York, exclusive makers of base-supporting rail joints, announce that their rail joints are now in use from ocean to ocean—the Panama Railroad being their latest equipment.

Allis-Chalmers Company has engaged for its office in St. Louis, Mo., a new suite of offices located at 1302-1304 Third National Bank Building, where the company's district manager, Mr. F. L. Bunton, and the salesmen of his staff will be prepared to receive visitors after January 1, 1908.

An unusual opportunity presents itself for men and boys to learn within two to three months the electrical and other trades, as the Coyne Trade School of New York has demonstrated, by the practical and individual instruction given in their schools that serving an apprenticeship to a trade is no longer necessary. In this school, tools take the place of books, and the student engages in actual work. In the electrical department he does all kinds of wiring, installs light, phone and telegraph systems, and learns to control, take care of and install motors and dynamos. This department is complete in every detail.

The Wisconsin Engine Co., Corliss, Wis., has taken up the manufacture of gas engines under the Sargent patents.

The Studebaker Company have delivered to the H. B. Claflin Company, New York, three of an order for six heavy electrical trucks weighing 8400 lb. Each driving battery consists of 44 cells weighing 2600 lb. New York saw the unusual spectacle of three huge automobile trucks running down Broadway each carrying a pair of large horses inside and drawing the horse truck behind the electric truck.

The Long Island Railroad will use concrete pile foundations for the new conduit line in the North Shore Yards at Long Island City. The contract has been awarded the Raymond Concrete Pile Company, of Chicago and New York, by J. R. Savage, chief engineer. The conduit, which will be of concrete, will be 1100 ft. long, and will carry the feed wires for the electric system. The application of concrete piling to conduit foundations is a novel one, this being the first time such use has been made on a contract of any magnitude. The Abbott-Gamble Company are the general contractors.

A total of 69 units, aggregating 60,000-h.p. capacity, of the Curtis type of turbo-generator, manufactured by the General Electric Company, of Schenectady, N. Y., have been installed in Japan.

The receivers of the Westinghouse Electric & Manufacturing Co. have arranged to make the January payment on the coupon bonds, and have annuled the call for bonds.

The directors of the Westinghouse Airbrake Co. and Union Switch & Signal Co. meet to act on dividends. It is stated on good authority that the regular disbursements will be made.

In a special circular the American Telephone and Telegraph Company offers $250 in its 4 per cent. convertible bonds or $225 cash for each share of Western Electric.

Most of the Western Electric stockholders will accept the terms of exchange for American Telephone bonds reluctantly. Smaller holders would prefer cash exchange, if any.

The proposition is regarded as a plan of the telephone company to consolidate the finances of its various concerns, of which the Western Electric is the most profitable, earning about 40 per cent. in a normal time. Outsiders say that the telephone company finds this plan the most feasible way of solving the financial problem of the electric company.

Western Electric stock is quoted nominally at 190. The bond exchange is equivalent to 200 in bonds.

All offices now connected with Stone & Webster in Boston are now located in the firm's building, at 147 Milk Street, corner of Batterymarch Street.

Stone & Webster have now under their management over thirty electric railway, lighting, gas and water-power companies operating in widely distributed sections of the country, and a number of electrochemical and mechanical companies. In 1906 these companies paid over $2,000,000 in bond interest, and over $1,000,000 in dividends.

During the nine years that Stone & Webster have undertaken the management of properties, their companies have paid out $9,588,000 in bond interest, and $5,600,000 in dividends, a total of over $15,000,000.

The Public Service Commission, Second District, will hold a hearing, December 11th, on the petition of the Niagara Falls Lighting Co. for authority to issue $100,000 capital stock, and a mortgage for $500,000, and to issue $300,000 bonds under said mortgage; also for permission to construct an electric light, heat and power plant in the City of Niagara Falls.

The Philadelphia section of the Illuminating Engineering Society will meet Friday, December 20th, in the Assembly Room of the Philadelphia Electric Company.

The United States Civil Service Commission announces an examination on January 8, 9, 10, 1908, at many places to secure eligibles from which to make certification to fill two vacancies in the position of mechanical and electrical draftsman, one at $1,200 and the other at $1,500 per annum, in the office of the Chief of Ordnance, War Department.

Applicants should apply to the United States Civil Service Commission, Washington, D. C.