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THE ELECTRICAL AGE

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Modern Business-Getting Methods

By GEORGE HOWE, General Manager of the Metropolitan Engineering Company

THOSE who are familiar with the early history of the greater number of electric central stations in the United States remember with interest the days when the sole and only concern of the station was to produce current. Managers sat back in their easy chairs and waited for the public to come to them. So long as the plant was economical in operation and the yearly increase in business normal, it was considered that practically the ideal of mangement had been attained.

The spirit existed that the central station was a necessity to the public, not the public a necessity to the station. It mattered not whether the general offices were well appointed, or on a convenient thoroughfare, or whether there was any one at the office prepared to discuss the various merits of electricity; the only thing that was really necessary was the chief engineer to operate the machinery and a fairly good collector to collect the bills. Such a thing as advertising current, offering bargains in current, educating the public to the many and varied uses of current, opening up new fields of revenue—in other words, selling current—an intangible thing—with the same business shrewdness and aggressive up-to-dateness as would be adopted by any successful merchant in promoting his line of goods—was unheard of.

A SIGN MADE BY THE METROPOLITAN ENGINEERING COMPANY, OF BROOKLYN, SHOWING THE ADAPTABILITY OF THE ELECTRIC SIGN TO ANY STYLE OF TRADE MARK

But conditions have vastly changed now; in fact, so very much so that there are perhaps few industries where modern up-to-date business methods have been more widely exploited than in the sale of electric current. When a new invention for the utilization of electric current is put on the market to-day its very first promoters, its most enthusiastic friends, will always be found among central station men.

The uses of electricity are multiplying on every side. Almost daily a new field is opened up. Central stations supplying current are multiplying their output at a phenomenal rate. The keynote of the industry is "Push," its by-word "Push," its every thought "Push"; and the very best brains of the land have been employed right and left to do this pushing.

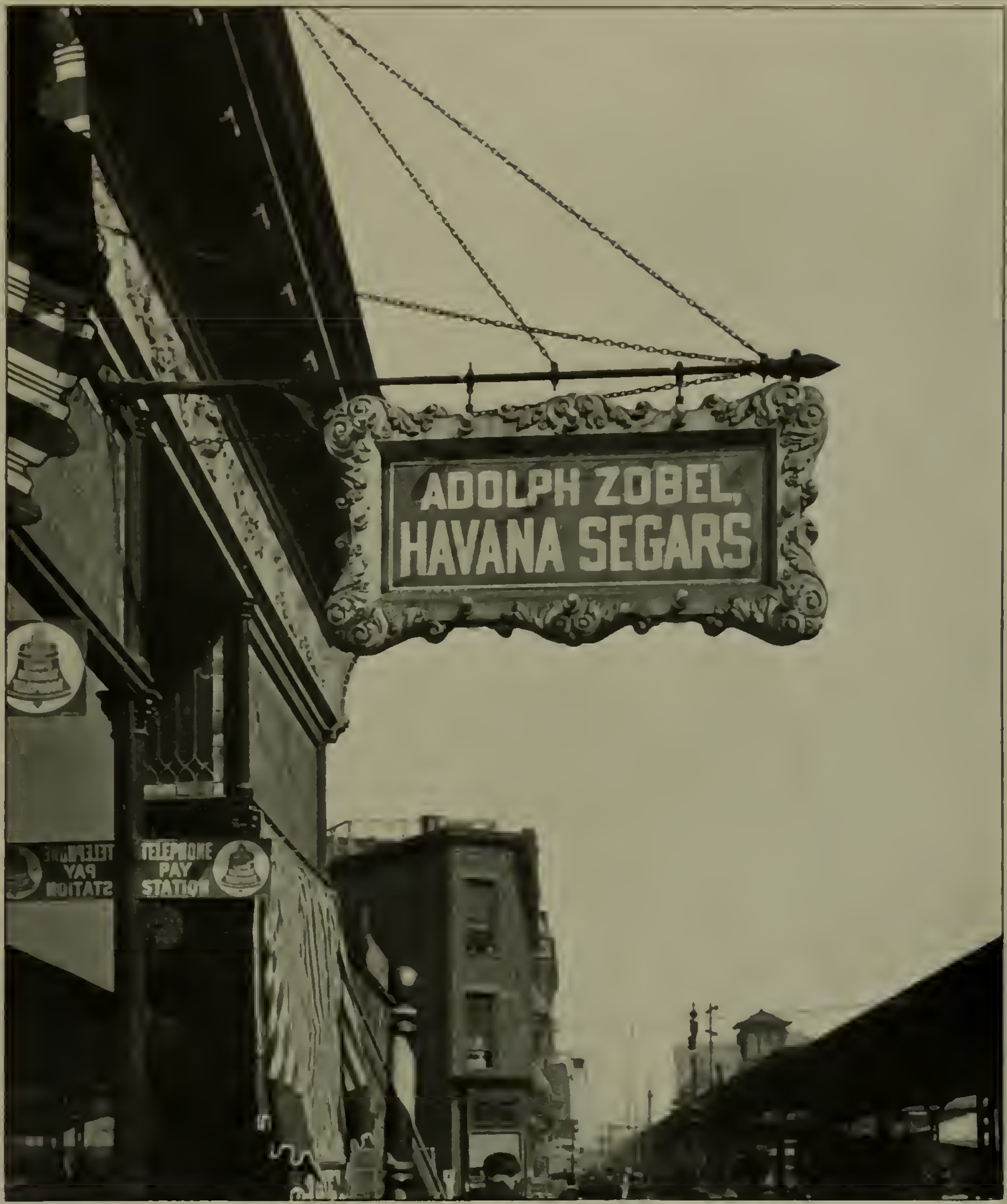
The first step to be taken in the

ONE OF THE MANY MODIFICATIONS OF THE REGULAR PANEL SIGN. THE LATTER CONTAINS A PANEL 17 X 47 INCHES, AND HAS TWELVE LAMPS ON EACH SIDE. THE SIGN SHOWN HERE HAS PANELS 24 X 72 INCHES AND SIXTEEN LAMPS ON EACH SIDE

A VIEW IN LONG ACRE SQUARE ON UPPER BROADWAY IN NEW YORK CITY, SHOWING THE EXTENSIVE USE OF ELECTRIC SIGNS FOR ADVERTISING PURPOSES promoting of any industry after the production has been established on a sane and solid basis is to develop a well-organized and aggressive sales department. This has been done and is being added to most extensively by every central station in the country whose management is at all up to date. The sales management of the larger companies is perhaps one of the most serious professions that have engaged the thought of men. The great New York, Boston, Philadelphia and Chicago companies employ hundreds of men in their sales departments.

A customer need no longer betake himself to a distant point to talk business with an illuminating company, but may go into a sub-office located in almost every prominent district of his city. If he is interested in power, he is referred to the "power department" and may receive expert information from a power expert on his requirements free of all charge to him. If he intends to put in an arc light he is referred to the "arc-light department," and may confer with the arc-light expert.

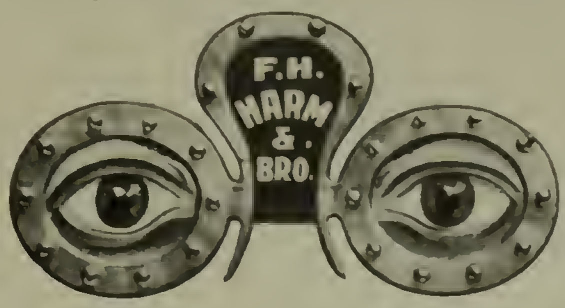
If his object is to inquire into the cost of electrical heating he is referred to the "electrical heating department." If he is a manager of a large enterprise which is operating its own plant and would like to consult on the cost of buying current instead of producing it, he is referred to the "private plant department," with its well-trained experts. More than this, every department and its branch in the various sub-offices employs a host of active, wide-awake canvassers and investigators, who usually find out about a thing long before the customer has really fully made up his mind about it. For instance a man putting up a new building is often surprised by a visit from the expert of the "new building department," who wishes to close a contract with him for the supply of current for his new building before he has officially announced his intention to build. A man operating a machine shop with an extensive system of shafting and steam power distribution is so unceasingly prodded about the uneconomy of his power distribution by one of the power experts that he almost invariably yields to their arguments.



AN ELECTRIC SIGN WHICH CENTRAL STATIONS HAVE UNIVERSALLY USED FOR THEIR FREE SIGN CAMPAIGN

A SIGN MADE BY THE WESTERN DISPLAY COMPANY, ST. PAUL, MINN. THE LAMPS ILLUMINATE THE TRANSPARENCIES AT THE TOP AND ALSO THE PANELS BELOW

To add to the efforts of all of these canvassers, specialists, experts, investigators and wide-awake promoters, a wide system of publicity may be found. "Follow-up departments," which write thousands on thousands of form letters every day and keep in touch with even the most unpromising propositions by their ceaseless efforts, bulletins edited in the most clever and attractive manner appealing to every phase of the public's vulnerability, circulars, announcements, notices, etc., are all in the general scheme of "Push."



A WESTERN DISPLAY COMPANY'S SIGN USED IN CONNECTION WITH A FLASHER

THE LARGEST VERTICAL SIGN IN THE WORLD. IT IS 100 FEET LONG, AND WAS BUILT BY THE METROPOLITAN ENGINEERING COMPANY, OF BROOKLYN, FOR THE DUANE STREET STATION OF THE NEW YORK EDISON COMPANY

Bargain sales have long been the traditional selling method; therefore the keen sales manager in the modern central station often offers to his customers and prospective customers bargain sales gotten up in the most alluring form.

But a bargain to be a good advertisement must be a real bargain. The public must get the best, so that it will forever congratulate itself upon its bargain. A problem that confronts the central station managers, then, is one of maintenance of their system and apparatus after the contracts and sales agreements have been made with customers.

Upon the effectiveness of the maintenance of an electric system the real financial success depends. If incandescent lamps be not renewed, if arc lamps be not kept in perfect operation, if meters be not tested properly, if the system be not properly balanced and adjusted, if, in other words, the maintenance be poor, very few contracts will stay closed.

Let us return to one phase of the aggressive business methods that have been adopted, the phase which is perhaps the newest and most interesting at the present time—namely, the electric sign proposition.

The electric sign is without doubt the most remarkable development in the line of profitable advertising that we have recorded in this decade. A few years ago the electric sign was a rarity, an unusual luxury, considered far beyond the means of the average tradesman. To-day, walk down any busy thoroughfare of a wide-awake city, taking New York as an example, and you will see not one, but a great number of electric sign-displays vying with each other in brilliancy and effect. Their phenomenal increase proves beyond the question of a doubt that they are most effective advertisements.

Note the central station's side of the question. Its customer has a sign, and has increased his business so much by its use that he will not be without it. The central station is furnishing him with current to operate this sign, and the cost of current for the sign alone may possibly be three or four times as much as the total bill for current formerly used in his establishment.

The smallest panel sign contains 24 lights of 4 or 8 candle power, usually the latter. An average individual letter sign would consist of from 100 to 200 incandescent lamps, while there are hundreds of enormous signs which contain from 500 to 1,500 incandescent lamps. Not only are the number of lamps large, but the hours of burning are steady and long. In fact, from every standpoint of this kind the electric sign offers a most profitable and desirable field for the sale of electric current.

There is another phase which has especially attracted the central station manager, and that is the wide advertisement of the use of electricity in general which is afforded by the electric sign. It is an old story in the proposition of advertising that the public's eye must be appealed to. The spectacle of hundreds of electric signs and displays so impresses the public with the uses of electricity that it will soon have nothing else. It becomes so convinced of the wide possibilities of the electric current, with its convenience, simplicity and economy, that electric current is soon displacing every other supply of energy. The service of the central station is advertised and re-advertised and the ball is kept rolling.

Moreover, a small store-keeper puts up an electric sign to develop his business; he soon becomes so attached to the advantages of electricity in his sign that he uses it in the store for lighting, instead of oil or gas. In a short while he buys a small motor to run his coffee grinder, then he puts in an electric lift, and so the story goes—all through the prime agency of the electric sign. This is not pure theory, but is the result of observation of the conditions in many cities. It has been the writer's good fortune to be thrown in contact with a great many central station men, and with one accord

SECTIONAL VIEW OF A SIGN LETTER MADE BY THE COLONIAL SIGN & INSULATOR COMPANY, AKRON, OHIO

they are strong believers in the electric sign for the many reasons above enumerated.

Conceding, therefore, that the electric sign is a particularly desirable proposition for the central station, let us consider some of the steps that have been taken and are being constantly taken by up-to-date central

REVERSE SIDE OF A COLONIAL SIGN LETTER SHOWING METHOD OF WIRING SOCKETS

stations for promoting their use. There are in general three distinct plans that have been widely adopted, namely, the rental plan, the current guarantee plan, and the installment plan. The titles of these plans are somewhat self-explanatory.

The rental plan consists briefly in the central station purchasing and installing a sign for the customer according to his requirements and exacting from him a certain monthly rental for its operation during a certain number of hours each night. The current guarantee plan is somewhat similar, except that the central station requires the customer to pay for the current used in the sign at the regular rates, and guarantee that the total use of current will not be less than a certain minimum amount each month. This enables the customer to keep his sign burning for very long hours for certain nights of the week, and for a short number of hours for other nights in the week if he so desires. In the installment plan the central station makes the outlay for the cost of the sign in every detail, charging the customer the regular rates of current for its operation, and requiring that he reimburse them for their outlay in certain monthly installments.

The rental proposition has been exploited perhaps more widely than the other two. It is reported that the Chicago Edison Company have installed more than three thousand signs on a rental basis. The New York Edison Company, in the lower "East Side" section of the city, have adopted the current guarantee policy for the installation of panel signs for their customers, whereas the same signs are installed on the upper "West Side" on a rental basis. It is said that the two systems operate equally as well.

The United Electric Light & Power Company, in New York City, have installed more than five hundred signs within the last year on the current guarantee basis, while the Edison Electric Illuminating Company, of Brooklyn, have for years reported success in installing signs on the current guarantee basis. In the borough of the Bronx, New York City, and in Yonkers, the current guarantee basis is also given preference. Such is also the case with the Public Service Corporation, of New Jersey, with the New York & Queens Electric Light & Power Company, the Westchester Lighting Company, the Albany Electric Illuminating Company, the Utica Gas & Electric Company and a host of other companies too many to enumerate.

Almost every one of the large companies and a great number of the progressive small companies have adopted one of the foregoing so-called free sign propositions, which, when examined carefully, are free in name only. In the West, particularly the Northwest, in St. Paul, Minneapolis, and Milwaukee, and cities in that section, the installment plan has been by far the most popular.

However, all the various propositions reduce to the following fundamtntal facts:—that the central station makes the outlay, assumes the initial expense, is repaid by the customer by some gradual method, and reaps its real benefit from the continued use of current in the sign. An outlay of fifty or one hundred dollars is quite a large one for a small trader, but he may be very glad to pay twelve or fifteen dollars a month for the benefits derived from such an outlay. The sum is trivial for the central station; therefore, when the central station comes forward and offers to pay the initial expense, it benefits not only itself, but its customer, and, even better still, the electrical industry.

It is interesting to note from the most recent records of one of the largest New York companies the following facts in connection with their free sign policy during the last twelve months. The company made an outlay of $13,000 for the installation of 400 electric signs, bringing in an annual revenue of $37,000. From this will be seen that the revenue per annum was more than three times

A VERTICAL SIGN MADE BY THE AMERICAN ELECTRIC SIGN COMPANY, BOSTON, MASS.

the outlay for electric signs, not to mention the many other incidental advantages in connection with it. Here was a case where the annual revenue of the company was increased commensurate with several hundred thousand dollars' worth of capital, and still only an expenditure of $13,000 was incurred.

To get more concretely at the facts of the case, on page 2 is shown a popular type of electric sign, known as the panel sign, which has perhaps been more universally used by central stations than any other type. This panel sign, known as the style No. 808, is considered a "winner," and while there are hundreds of other types of panel signs of more or less similar nature, we will consider the results from this style as typical of the rest.

AN INDIVIDUAL LETTER SIGN MADE BY THE FEDERAL ELECTRIC COMPANY, CHICAGO

This panel sign will be seen to contain 24 incandescent lamps, 12 on each side. It is called a panel sign because it consists of a frame in which are placed interchangeable panels bearing the customer's name and legend. From the central station's point of view this is desirable, as the sign may be used for another customer without any trouble save the repainting of the panels or exchanging them for new ones.

The total cost to the central station of this panel sign installed, together with all wiring from the service to the sign, averages about fifty dollars. Sometimes it is slightly more, but more frequently is slightly less.

A SIGN BUILT BY THE MOBILE ELECTRIC COMPANY, OF NEWARK, N. J., AND PLACED ON THE ROOF OF THE DENVER GAS & ELECTRIC COMPANY'S BUILDING DURING THE NATIONAL ELECTRIC LIGHT CONVENTION LAST YEAR

Some time ago the United Electric Light & Power Company, of New York, in adopting the free sign policy, wished to make a test of its merits, and ordered 50 signs, which were placed among its customers in the usual manner. The three worst months in the year were chosen—namely, June, July and August—three months when the days are very long and the hours of illumination short, when trade is slack and when the most discouraging conditions could be encountered.

A separate meter was placed on each sign so as to indicate the consumption of current of each; the customer was made to guarantee a monthly use of at least $3 worth of current at the regular retail price of 10 cents per kilowatt-hour. During the three months in question the average use of current from these fifty experimental signs was $7 per month, or a yearly revenue of $84 per sign. The initial expenditure to the company in installing these signs was $50 each, including all expenses.

In normal conditions of lighting, taking winter, summer, and other seasons when business is brisk and the days short, there is very little doubt that the total revenue per sign would exceed $150 per annum, and all of this with an initial expenditure of $50. Business that would not ordinarily have been obtained, revenue that otherwise would never have been added to the company's credit was thus created. It is unnecessary to add that the experience of this central station immediately decided it upon the adoption of the free sign policy in the broadest sense.

Very little in the electric sign proposition is a matter of conjecture, however. If the central station manager knows the number of lights in the sign, the candle-power of lamps which he intends to use, the number of hours during which the sign is to burn, and the rate he intends to charge for current, he may very easily calculate for himself the monthly bill. It is then a very simple matter, if he knows the cost of the sign, to determine just how many times over the sign will repay the investment for itself in one year.

One more word as to minimum guarantees. It is usually customary among central stations to require a minimum bill of at least $5 per month from the customer for a panel sign when it is installed free. Exceptions to this rule are many, but it is considered a fairly good rule. Where the rental proposition is in vogue and the sign is rented at a flat rate per month, independent of the amount of current which it consumes, it is customary to charge $2 per week, or about $8.50 per month for rental of a panel sign of 24 lights.

The individual electric letter sign, similar to that shown on page 4, is usually rented on a basis of $1.50 per letter per month, considering the use of a letter 18 inches tall. With a larger or smaller letter the cost is proportionate.

Before closing, the writer wishes to mention a particularly clever business move on the part of an active central station manager in New York State. His company obtained a fine advertising site and placed an enormous electrical sign on it reading that "Mr. Blank, operating the magnificent Blank department store, is a prominent user of our electric current." These names were changed from day to day, the complete circuit taking a number of days. In a short while the large department stores using the central station current had so multiplied that more than a month was taken to make the circuit. The advertising value of an electric sign became so conspicuous that they multiplied on every side. To-day the city in question, although a small one, contains some of the most profuse displays of electric light and electric signs of any city of its size in the State.

The Illuminating Engineering Society

MEETING IN NEW YORK, JUNE 8

THE last meeting of the Illuminating Engineering Society for the summer was held in the Edison Auditorium, 44 West Twenty-seventh street, New York, Friday evening, June 8. About forty members were present to hear Dr. Louis Bell's paper on "Some Physiological Effects in Illumination and Photometry" read and discussed. Dr. Bell was detained in Boston by a patent suit, and, therefore, was unable to be present, but his paper was read and listened to with interest by those present.

The purpose of the paper was to point out some of the bearings of physiological optics upon practical illumination, its measurement, and the limitations of its efficiency.

Save for the effects of accommodation and convenience in determining vision in three dimensions, we see things wholly by their differences in colour and in luminosity. If two objects are of the same colour and luminosity they cease to be separately distinguished, and as they approach this condition they become progressively more and more indistinct as individual forms. If the difference of luminosity is small, the colour difference must be increased to secure visibility, and vice versa.

According to Fechner's law, the human eye can perceive a fixed fractional difference of illumination, irrespective, within wide limits of its absolute amount. This fraction varies in general from about 1 per cent. to about 0.55 per cent., assuming ordinary sources of illumination and normal eyes. At 1 or 2 foot-candles, however, the eye is working so near its normal sensibility that further increase in illumination is of relatively very small value.

If the conditions are such as to require powerful illumination in a part of the field, a very bright background in the rest of the field should be avoided, it being preferable to have there merely enough light to avoid excessive contrasts.

As most objects are coloured, the relative luminosities of various colours are important considerations in illumination. That the eye is affected by various colours in very different degrees is well known, and the fact is responsible not only for great difficulties in photometry, but also for serious limitations on the possible efficiency of illuminants.

Were it not for the adjustment of the eye for a sharp maximum of sensibility, we should be totally unable to see clearly on account of the effect of chromatic aberration. When the eye is accommodated for yellow light, images due to deep red and deep blue light are badly out of focus, and were they comparable in brightness to the yellow image, near vision would be very indistinct. Aside from this, we should lose much of the contrast which helps to render objects visible.

The efficiency of an illuminant in the sense in which the expression is ordinarily used, is the ratio between the luminous energy and the total energy. If one could confine radiation to the visible spectrum with as good a distribution as is given by the Welsbach or by sunlight, one could secure artificial light on a duty of about 0.06 watt per candle-power. This, however, is not the limit, for if in addition one could crowd all the radiation into the neighbourhood of wave length 590, one could get light at a duty of approximately 0.01 to 0.02 watt per candle-power, which is about the theoretical minimum. This would, however, be practically monochromatic light, by which colour vision would be impossible.

The flaming arc is the most efficient illuminant yet found, and M. Blondel has been able to obtain from it a duty in the vicinity of 0.1 watt per mean spherical candle, due to the very high luminosity of the two calcium fluoride bands near to wave length 600 mm. But the light has a large colour error which can be corrected only by a considerable sacrifice of efficiency. Undoubtedly, a discontinuous spectrum gives the best chance for high efficiency, but only at the cost of serious colour errors. Even if one could obtain a discontinuous spectrum of the three primary rays only, it would be at a sacrifice, and there would be some doubt of its value as an illuminant on account of chromatic aberration in the eye.

Could one steal the fire-fly's secret, the result would be, if Langley's experiments correctly represent it, a light of high efficiency, it is true, but of about the colour of a superannuated Welsbach. From all appearances, it will be extremely difficult to do much better than a duty of 0.5 watt per candle with an illuminant of reasonably good colour quality.

DISCUSSION

Dr. Fredenberg brought out some interesting points regarding the general effects of light on the eyes. He thought the incandescent electric lamp the best artificial light for close work, because it could be brought nearer the eye than other lights without heating and drying the surface of the eye and thus causing pain. He spoke of temporary blindness caused by electrical discharges, and said it seldom, if ever, happened that a person became permanently blinded in this way. For general lighting, he considered the intensity and distribution of the illuminant more important than the wave length. The sources of light should be concealed as much as possible. Public places he believed were, as a rule, too highly illuminated. Regarding fatigue of the eyes, he said that white light was less tiresome than any coloured light because the former stimulated a greater number of fibres, so that there was less strain on any one set of them. Walls of gray with blue or yellow form restful backgrounds for the eye.

Dr. Dennett called attention to the common custom of reading with a strong light on the book, but with the rest of the room dark. He considered this practice tiresome to the eyes on account of the strain produced on them by the sudden change from light to darkness whenever glancing off the book.

Mr. Cravath spoke of the light required in draughting. He claimed that in tracing, 10 foot-candles should be used, but that ordinarily much less light than this was provided. He presented the question, "Is it good practice in a theatre to have the stage brilliantly lighted and the auditorium dark, as is usually done?" Those who spoke in answer to the question believed that it would be less trying on the eyes if the auditorium was given a low light during a performance on the stage.

Mr. Elliott discussed the idea of having too much light for general illumination. He believed that this was possible, and that the case was similar to that of the stomach when overloaded with food. Strong lights above the line of vision are fatiguing, he said, because the rays strike the eye at an unusual angle.

At a meeting of the council of the society, the following resolution was unanimously adopted:—"In order to distribute as equitably as possible the benefits and privileges of membership in the Illuminating Engineering Society, the organization of sections is authorized in any city or locality where the local membership is at least fifty. The membership of New York City and vicinity shall be organized as a section, to be known as the New York Section of the Illuminating Engineering Society. Each section organized shall nominate and elect for the local conduct of the section a chairman, two vice-chairmen and a secretary. The expenses of sections incurred for postal-card notices and stenographic report of discussions shall be paid from the general fund of the society. Other expenses than these, such as rent of auditorium, if any, must first be authorized by the council. In order to insure that the conduct of sections shall always be in conformity with the general policy of the society, any proposed action of a section not relating to the holding of meetings and the discussion of papers shall be submitted to the council of the society for approval prior to being put into execution. In order to facilitate the prompt issue of the transactions, the meetings of all the sections shall be held before the 20th of the month. The secretary of each section shall distribute the stenographic reports of discussions to members of the section for correction, and forward the corrected report to the general secretary of the society. The sections shall abide by the constitution of the society and conform to the regulations of the council."

The enrolled membership of the society on June 8 was 572.

Electric Plant Concessions in Colombia

According to United States Consul P. P. Demers, of Barranquilla, Colombia, the government has granted to Francisco E. Baena, president of the Baranquilla tramway, an extension for thirty-nine years of a previous concession for the building and operating of an extensive tramway. It is the intention of Mr. Baena to develop the enterprise with American capital and equip the whole service with American cars and machinery.

The new concession includes the obligation to put into service modern cars, substitute electric traction for that of animals, and to extend the lines to Soledad and Sabanalarga. Barranquilla has about 50,000 inhabitants, having gained 30,000 in the last twenty years. Soledad and Sabanalarga are, respectively, six and thirty-six miles distant from Barranquilla, between which there is extensive cart and mule-back traffic over hot sandy roads. The tram company has also been granted an electric light franchise. Copies of the concession can be seen at the Bureau of Manufactures.

The successful establishment in Colombia of a modern trolley and electric light system under American management and capital will be a good step toward the introduction of American commerce there. To-day there is practically nothing American in the Barranquilla district except the ownership of a few outlying mining industries in adjacent States.

Another South American concession is that reported by Vice-Consul A. O. Wallace, of Managua, Nicaragua. The city of Leon, Nicaragua, has given an electric light and power plant contract to René John La Villebouvre, an American residing at Managua. The city takes 100 arc lights of 1200 candle-power each, and absolves the contractor from all taxes, gives him the free use of any municipal lands and all the building material for construction; also guarantees to obtain free of duty the importation of all needed machinery and tools for thirty years, —the life of the contract. The plant is to be installed within eighteen months, and is to be sold to the highest bidder at the end of the thirty years' term.

Municipal Ownership Report for the American Street and Interurban Railway Association

At the convention last year of the American Street and Interurban Railway Association, a committee was appointed to make a general investigation of the question of municipal ownership, and to report at the 1906 convention, which is to be held at Columbus, Ohio, in October. The committee consists of C. D. Wyman, chairman; J. J. Stanley, H. M. Sloan, John A. Beeler, and Geo. F. Chapman.

In order to secure the opinions of street and interurban railway corporations on this subject, a list of questions was issued, containing in part the following:—

What municipally owned utilities are now in operation in your city or field of operation?

Has there been any agitation for the municipal ownership of street railroad properties?

What have been the sources or causes of such agitation?

Has there been any expression regarding it by votes or taxpayers?

Has your company made any public statement of its position with regard to the question?

Has the agitation affected the company in its efforts for renewal of old applications for new franchises?

Would you suggest a discussion of this question in open or executive session at the next convention?

What, in your opinion, is the best method of overcoming the sentiment for municipal ownership?

The material obtained from the answers to these questions, together with other material obtained by the committee, will be embodied in the report.

Another committee, consisting of W. E. Harrington, chairman; H. F. Grout, and H. E. Reynolds, are to report on methods of promoting traffic.

The German iron ore production for the first quarter of 1906 amounted to 3,005,982 tons. The production for the same period of 1905 was 2,334,500 tons.

A Mercury Arc Rectifier System With Magnetite Lamps for Street Illumination

By W. S. BARSTOW

A Paper Read at the Atlantic City Convention of the National Electric Light Association

MANY times in the history of the electrical industry the end of a particular commercial development appears to be near at hand, only to be indefinitely postponed by a new discovery in this or some other allied science which accidentally opens up new possibilities. Often, again, the failure in some special line is caused by the absence of a single element which, when forthcoming, turns the failure into an important success. Sometimes all the elements are present, but scattered through different industries, so that there is not a sufficient familiarity or knowledge in the hands of any one person or group of persons for a combination to produce the desired result.

Among all the radical changes in the details of the industry during past years the electric arc lamp has shown but little material progress. It is true that there have been evolved the high-tension, the low-tension, the open, the enclosed, the direct and the alternating-current systems, with their many modifications, but in none of these has there been any departure made from the carbon arc and its relatively uniform efficiency for a given illumination. From the day of Sir Humphrey Davy, in 1808, when with a battery of 2000 elements he produced his 4-inch flame between charcoal points, to the present refinement of the 150-hour enclosed lamp, progress has been confined more or less to mechanical improvements. The commercial arc lamp of the early days was of open-arc type, requiring 500 watts at the arc to produce what was then termed a "nominal" 2000-candle-power light, or a certain illumination. After passing through the series and multiple stages, the enclosed lamp was evolved, economical in maintenance, but with no improvement in consumption of energy. This in the direct and alternating-current form is the type in general use to-day.

There has during the last two years been in course of development a new system (if it may be so called) for outdoor street arc lighting, which not only promises to take an important place in the history of the art, but in many instances to replace the carbon arc. It is actually the first successful effort to increase commercially the efficiency of outdoor arc illumination, while at the same time it opens up new fields where the present type lamps cannot be used. The magnetite mercury arc rectifier system requires not only 35 per cent. less energy at the lamp than any existing system for the same illumination, but makes it possible to do outdoor street arc lighting from transmission systems of 35 cycles and under without the use of motor-generator sets or other moving apparatus. In the city of Portland, Ore., about two years ago this system was installed on a small experimental scale. The street lighting system at that time had been in successful operation for many years and was of the old style open-arc type, supplied with direct current.

In the very early days current supplied to Portland was generated by water-power at Oregon City, about 17 miles south of Portland, and was transmitted to Portland for arc and incandescent lighting. As all arc lighting was done on the high-tension system, and incandescent lighting on the high-frequency, single-phase system, each machine had a separate set of feeders from Oregon City to Portland. (This was one of the first instances where, previous to 1892, single-phase, high-frequency machines were operated at a direct pressure of over 4000 volts.) The business increased so rapidly that in 1891 there was transmitted in actual commercial capacity energy for 7200 incandescent and 650 arc lamps by means of the systems above mentioned. As business grew and electric railways were installed in Portland, a second power plant was built at Oregon City, and a 33-cycle, three-phase, 5000-volt system installed, with direct-connected vertical wheels, especially arranged for a head varying from 15 to 45 feet, and current was transmitted from there by rearranging the original arc and incandescent circuits, each generator being connected to a single three-conductor, three-phase feeder. To each feeder in Portland were connected a set of statics and a rotary transformer, so that there were practically a number of independent generating and transforming plants. To provide for the city lighting, motor-generator sets were installed in Portland, each set consisting of a direct-current T.-H. motor, directly connected to two direct-current arc machines. Thus, in these early days several transformations were necessary before the alternating current delivered to the sub-station was finally distributed to the system, and it required 806 watts per lamp of the transmitted energy in the form of 33 cycles, 5000 volts, three-phase, to supply each 500-watt lamp installed in the city. In remodeling the system, as no arc lighting could be taken from the transmission frequency of 33 cycles, it was either a case of using alternating-current, high-tension motor-generator sets, changing the frequency from 33 to 60 cycles, or a high-tension motor directly connected to direct-current arc machines. Under these conditions, and with the original idea of reducing motor-generator capacity and the investment in generating system, several magnetite lamps were installed as an experiment about two years and a half ago, and from that time to the present modifications and improvements were made until now the lamps are equal in all respects to any arc lamp of either alternating or direct-current system. In the meantime lengthy experiments were made with the mercury arc rectifier. About one year ago the results appeared so promising and so much progress had been made in such a short period that an order was placed to install the entire system of over 1200 lamps in Portland with mercury arc rectifiers and magnetite lamps. There have now been in operation in Portland for several months over 800 lamps with rectifiers, and the installation is being rapidly increased as fast as deliveries can be made. The system has proved successful and has fulfilled expectations. Considerable difficulty in the form of static discharges and short life was at first experienced with the tubes. The tubes, which were of small size, were subjected to very rigid requirements on account of the alternating-current pressure of 18,000 volts, a pressure which was very much higher than anything yet attempted with mercury arc rectifiers. The tubes have now averaged over 650 hours, and several have exceeded 730 hours, 500 hours being the economical requirement, and anything above this being in the nature of a gain in the original calculated efficiency of the system.

A simple description of the system as installed is as follows:—The transmitted energy in the form of 10,000-volt, three-phase, 33-cycle current enters constant-current transformers, each transformer being of single-phase design, the primary of which is wound for 10,000 volts, and the secondary for 16,000 volts. In the secondary is a centre connection for the rectifier. The mercury arc rectifier is mounted upon a switchboard panel directly above the oil switch. It is excited by a small amount of 115-volt alternating-current energy. This is sufficient to start the rectifier after the same has been moved slightly with a handle for that purpose in order to establish the mercury arc. It requires but a few seconds to start up a circuit, and, when once started, it is not necessary to maintain the exciting circuit in operation, although this has been the practice up to the present time. In each alternating current side of the transformer is placed a reactance, and another in the direct-current side. The lamps themselves require four amperes at an average of about 80 volts, or 320 watts, and give an equal illumination to the old-type open lamp requiring 500 watts. As the original distributing system was installed for 10-ampere lamps, losses in these conductors have of course been reduced to a minimum. The present lamps are installed in units of seventy-five lights. An extra transformer panel with rectifier is provided, so that in the case of any accident happening to the transformer or rectifier, the circuit can immediately be plugged in on the spare set. The lamps themselves are, no doubt, familiar to many, as they have already been described in some of the technical papers.

The efficiency of the rotary transformer motor-generator system, as originally installed in Portland to take care of the street arc lighting, from the alternating-current transmitted energy to the direct-current energy distributed to the lamps, was 62 per cent. at or near full load (which is the prevailing condition).

The efficiency of the constant-current transformer mercury arc rectifier system from the alternating-current transmitted energy to the direct-current energy distributed to the lamps is at full load 88 per cent. (at 10 per cent. overload, 89 per cent); at three-quarter load, 85 per cent.; at half-load, 81 per cent., and at one-quarter load, 80 per cent. The efficiency was obtained by measuring the true watt input of the primary alternating-current energy and the true watt output in direct current, and includes all transformers and reactances, but not the small fan motor used to cool the rectifier tube.

Having thus effected a saving of 26 per cent. in the efficiency of the transforming system itself in Portland, the company secured further economy by the use of magnetite lamps, using 320 watts in the lamp in place of the 500 watts, thus obtaining for 364 watts of transmitted energy the same illumination that originally required 806 watts, or a saving of 1768 KW.-hours per lamp per year; or on the total Portland installation a saving in capacity of 531 KW., and a saving in total energy of 2,121,600 KW.-hours per year.

The efficiency of a standard motor-generator set using a high-voltage motor and direct-current arc generator is about 76 per cent., so that if in a modern installation where low-frequency alternating current is transformed by synchronous motor arc machines into direct-current energy for present type of 500-watt arc lamps, there should be installed the constant-current transformer mercury arc rectifier system with magnetite lamps, the gain in efficiency for the same illumination would amount to 294 watts per lamp or 1176 KW.-hours per lamp per year.

The high commercial efficiency of the latter system is due to a very large extent to the simplicity and economy of the rectifier tube itself. A tube of a capacity of about 30 KW. has a constant loss of but 25 volts, or, at four amperes, 100 watts per hour, while the cost of renewing the tube on the basis of 500 hours' life about equals the cost of labour and renewals on a motor-generator set.

Owing to the fact, that both parts of the alternating-current waves are used, the voltage of the alternating current leaving the transformers to the rectifier tube to produce a desired voltage in distributed direct current, must be about three times the desired direct-current voltage required by the lamps in circuit. Thus, about 18,000 volts on the secondary of the transformer tubes gives a useful direct-current voltage of about 6000.

In the use of the magnetite system a commercial question arises, which, after very careful consideration, should be definitely answered before the system is adopted to any great extent. I refer to the specifications used in the present public lighting contracts. About fifteen years ago considerable thought was given to the subject by this association, resulting in a campaign of public education which produced the proper result at that time of rating street arc lamps by the "watts in the arc" and dropping out of contracts the terms "normal candle-power." If the price of public lighting is to be fixed by "watts in the arc" on the same basis as present cost, the public will profit by this lamp (due to lamp efficiency) to the extent of 36 per cent., the company gaining in transformer efficiency to an extent of 17 per cent.

The question as to how the public and the companies should share this gain so as to determine under what specifications the illumination should be furnished is a broad one and is a matter that should be carefully considered at this time, so that the introduction of this new system shall be accompanied by a proper standard form of specifications.

A Rubber Exhibition in Ceylon

A RUBBER exhibition, under authority of the Ceylon Government, will be held in the Royal Botanical Gardens, Peradeniya, Ceylon, from September 13 to September 27 next. This will be the first exhibition of its kind ever held.

Rubber is now being cultivated in Ceylon and the Federated Malay States, and though the exports as yet are inconsiderable, they are doubling annually, and will, in about seven years' time, probably reach ten or fifteen million pounds. It is expected that in fifteen years from now they may exceed the exports of Brazil.

Vessels passing through the Suez Canal are required to carry an electric searchlight. Ships not so provided can hire an outfit at the entrance.

The Power-Transmission System of the Long Island Railroad

By W. N. SMITH

FIG. 1.—THE TRANSMISSION LINE OF THE LONG ISLAND RAILROAD CROSSING A TRACK. THE CABLE RETAINERS ARE SHOWN ON THE POLE AT THE LEFT

GENERAL FEATURES OF THE POWER TRANSMISSION LINE

THE lines of the Long Island Railroad first equipped with electric power comprise the Atlantic Avenue division between Flatbush terminal and Belmont Park, and the Rockaway Beach Division between Woodhaven Junction and Rockaway Park. The equipment of the latter division has also been extended to enable electric operation via Far Rockaway and Valley Stream.

A study of the traffic conditions to be met by the electric equipment upon these divisions resulted in a preference for sub-station sites at Woodhaven Junction, East New York, Flatbush Avenue, Rockaway Junction, and Hammel. These were ultimately selected as permanent sub-station locations, except that Grand Avenue, about one mile out from the terminal, was later substituted for Flatbush Avenue. Since the original installation described in this article was completed, a sixth sub-station has been located at Valley Stream, receiving its power from an extension of the overhead line by way of Springfield Junction.

Two portable sub-stations were also provided as the most economical method of supplying current for the very heavy periodic traffic to and from the Metropolitan race track south of Jamaica, and the new Belmont Park race track about five miles east of Jamaica. These loads occur for two hours each day, for periods of two weeks, twice a year. The portable sub-stations consist of 1000-K. W. rotary converter outfits, complete with transformers and switchboard, each mounted in a heavy steel box car.

In reaching a decision as to whether the overhead or underground type of construction should predominate, a very careful study was made of the record of experience in operating lines of great length and of large carrying capacity. It appeared that the troubles in overhead lines were generally from the following causes:—Wind, lightning and sleet storms; structural weakness of poles, cross arms, pins and insulators; outside interference either from branches of trees or mischief makers and thieves; and very rarely, by heat from a conflagration close to the route.

In case of conduit construction, it was found that breakdowns were generally due to capacity effects causing extraordinary voltages, to depreciation of cable sheaths from electrolysis, or to short circuits by reason of mechanical injury, imperfect insulation, or failure of joints, and occasionally to overloading or to gas explosions in manholes.

Comparing the causes and effects of the troubles in the two classes of construction, the general conclusion was reached that, while an overhead line is liable to more frequent interruption through minor troubles than an underground line, the interferences with continuous operation on an underground line, when they do happen, are likely to be of a more serious character, and of longer duration. Although underground con-

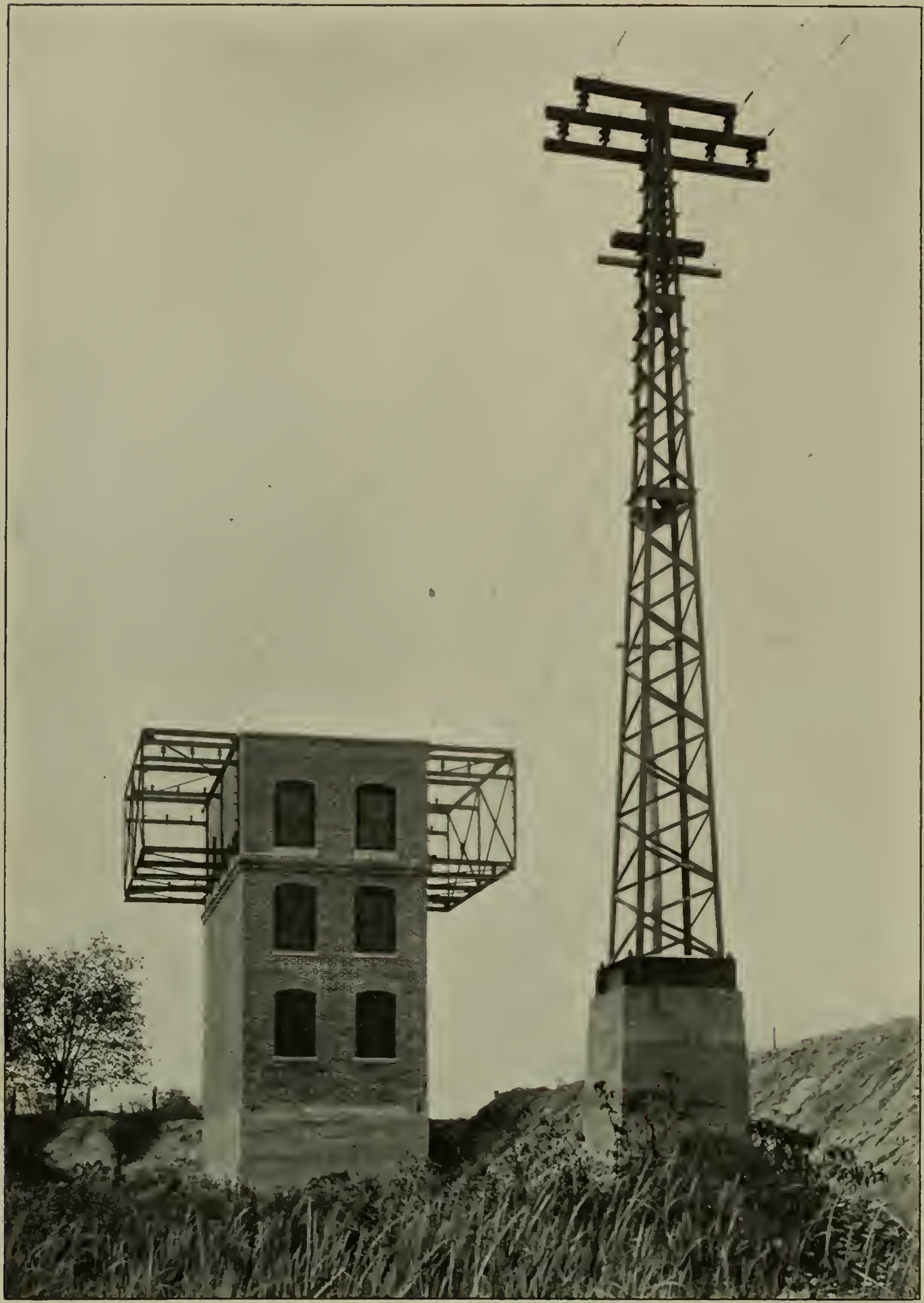


FIG. 2.—AN ARRESTER HOUSE AT DUNTON. WHENEVER THE UNDERGROUND CABLE IS JOINED TO THE OVERHEAD SYSTEM, LIGHTNING ARRESTERS AND CHOKE COILS ARE INSTALLED IN SUITABLE HOUSES

struction might have been preferred, could its cost be brought down to something like an equality with overhead costs, financial considerations favour the adoption of the overhead type because its cost is only a fraction of that involved in high-tension cable and conduit work, and because its reliability is assured when properly installed. Overhead construction was therefore adopted wherever it was usable.

The topography of the system is such that the Woodhaven Junction sub-station becomes a natural distributing center between the power house and the other sub-stations. The problem of line construction was therefore to build a trunk line from the main power station to Woodhaven Junction, with two branch transmission lines running along Atlantic Avenue between Grand Avenue and Rockaway Junction with two subordinate branches from Rockaway Junction to the two race tracks, and a third subordinate branch running directly south from Woodhaven to Hammel sub-station, across the Jamaica Bay trestle.

The impracticability of constructing high-tension overhead lines in thickly populated sections of Brooklyn and Queens, required recourse to underground construction in two sections of the line. Except where submarine cables were used at the drawbridges in the Jamaica Bay trestle, the remainder of the transmission line is of the overhead type of construction.

The trunk line as originally built carries five circuits from the power station to Woodhaven Junction substation, running part of the way in an eighteen-duct conduit line and the remainder on a line of steel poles.

The general arrangement of the transmission circuits is shown in Fig. 3. It will be noted in this diagram that the incoming trunk line circuits at Woodhaven Junction are distributed along a set of bus bars called the "transfer buses," and divided into sections from which the outgoing transmission circuits lead in various directions. It is possible by manipulation of the bus junction switches to operate these circuits separately or together, from outlying sub-stations all the way back to the power station. The same general arrangement is carried out in a smaller degree by similar transfer buses at East New York and Rockaway Junction.

The lengths of the various sections of the transmission lines are as follows:—

Conduit section of trunk line, power station to Dutch Kills Street, 1.12 miles. Overhead trunk lines, Dutch Kills Street to Woodhaven Junction, 7.85 miles. Conduit section from Woodhaven to East New York, 3.23 miles; from East New York to Grand Avenue, 3.04 miles; from Woodhaven to Dunton, 1.7 miles. Overhead from Dunton to Rockaway Junction, 1.73 miles; Rockaway Junction to Belmont Park, 3.71 miles; Rockaway Junction to Springfield Junction, 3.55 miles; Springfield Junction to Valley Stream 2.57 miles; Woodhaven Junction to Hammel, 6.98 miles. The total mileage of conduit lines now in use is therefore 9.09, and that of pole lines 26.19 miles.

CONDUIT CONSTRUCTION

Between the power station and the railroad tracks, part of the conduit construction was rendered especially difficult because much of it was situated below the level of the ground water, which, for a large part of the distance was nearly at the surface, so that special provision for the drainage of the ducts and manholes was necessary.

The manholes in this part of the line are connected by a line of 8-inch sewer pipes laid beneath the ducts and entering the manholes about 18 inches from the bottom thus forming a catch basin to prevent silt or other foreign matter from getting into and clogging the pipes. This conduit line is so pitched as to bring all the drainage into three sumps, one located at the power station, one about one-half mile from it, and the third near the Dutch Kills Street end of the conduit line. These sumps are kept pumped out by electrically driven submerged centrifugal pumps, automatically controlled and discharging into the city sewer system.

This conduit line is constructed of single vitrified clay ducts 18 inches long, with square holes 3 13-16 inches inside measurement, and walls $\frac{3}{4}$ inch thick. They were designed especially for this construction, and the ducts are 7-16 inch greater in diameter than usual in order to facilitate the installation of the three conductor high-tension cables, which are nearly 3 inches in diameter.

A single duct was preferred to multiple ducts because of the thicker wall between ducts, which is better able to resist heat in case of a possible short circuit. A square hole with rounded corners was preferred as affording space for dirt and pebbles to slide to one side instead of being dragged along underneath the cable and injuring the sheath as would be the case if round ducts had been used. The ducts are laid in cement mortar in such a way as to break joints in all cases, and are surrounded on the top, bottom, and sides by a covering of concrete 4 inches thick composed of one part Portland cement, $2\frac{1}{2}$ parts sand and 5 parts broken stone. The ducts are arranged three wide and six high.

Manholes for drawing in and splicing the cables are located 400 feet apart on straight work and a shorter distance apart on curves. The standard manhole for straight line work is 8 feet long, 4 feet wide, and $6\frac{1}{2}$ feet high, inside dimensions. The corners are cut off so that a horizontal section of the manhole resembles an elongated octagon.

UNDERGROUND CABLES

The underground high-tension cables are of the three-conductor type, each conductor having a cross-section of 250,000 c. m., and being composed of 37 copper wires. Each conductor is covered with a wrapping of impregnated paper 7-32 inch thick. The interstices between the insulated strands are filled in with jute insulation and another layer of 7-32 inch thick paper insulation is wound over the entire group. The outside sheath is 9-64 inch thick, and is composed of lead with about $1\frac{1}{2}$ per cent. of tin added. The completed cable is $2\frac{1}{8}$ inches outside diameter.

Each length of the cable was tested at the factory by applying 30,000 volts between each pair of conductors, and between each conductor and the sheath. After the cable was installed in the ducts and jointed up ready for service, it was again tested by applying between each pair or conductors 30,000 volts, and between each conductor and the sheath 27,000 volts for a period of 30 minutes.

At each end of every high-tension cable there is sweated on a spun brass end-bell, which is filled with "No. 67" G.E. compound, to properly seal the ends of the cable and prevent injurious static discharges. The end-bell is about $7\frac{3}{4}$ inches in diameter and about 7 inches high. The three conductors are brought out separately through a wooden head in the end-bell, after being wrapped with varnished cambric tape, and are surrounded by micanite tubes to give additional insulation.

At the drawbridge in the Jamaica Bay trestle, the cables are of the armoured submarine type, and the conductors are insulated with 7-32 inch of rubber around each strand with another 7-32 inch of rubber around the group of three. This insulation is composed of 30 per cent. pure Para rubber and is covered with a sheathing 9-64 inch thick, and composed of lead with about $1\frac{1}{2}$ per cent. of tin added. Over this is an armour of No. 4 B. & S. galvanized iron wires laid spirally on the outside of the lead covering with a thin layer of jute between the lead and the armor. There are two such cables at each drawbridge.

The high-tension cables are located in the lower portion of the conduit system wherever possible with the idea of separating them from any other cables for different purposes which may be installed subsequently. They are carried around the sides of the manholes in racks. The minimum radius of the bend in this type of cable is 18 inches. At each manhole, there is a strip of sheet copper sweated on to the lead sheath of the cable and brought out through the wrappings to allow of grounding the cable should it be necessary to protect it from electrolysis.

Before the cables were pulled into the ducts, a wooden mandrel 3 feet long and $3\frac{1}{2}$ inches in diameter was pulled through to insure a clear passage. At the Jamaica Bay drawbridges, the armoured cables were laid across the channel and allowed to settle to the bottom. A diver then arranged them so that they were properly separated, and they were sunk into the mud by means of a water jet, supplied by pumps at 100 pound pressure. By means of this jet, the diver was able to scour out a trench wide enough to contain the cables, 4 feet below the bottom of the channel.

This method of installation was preferred to dredging, because of the difficulty which would have been encountered in attempting to dredge the trench through the fender piles on either side, and because of the rapid current through the channels, which would fill with sand a trench so dredged immediately after exca-

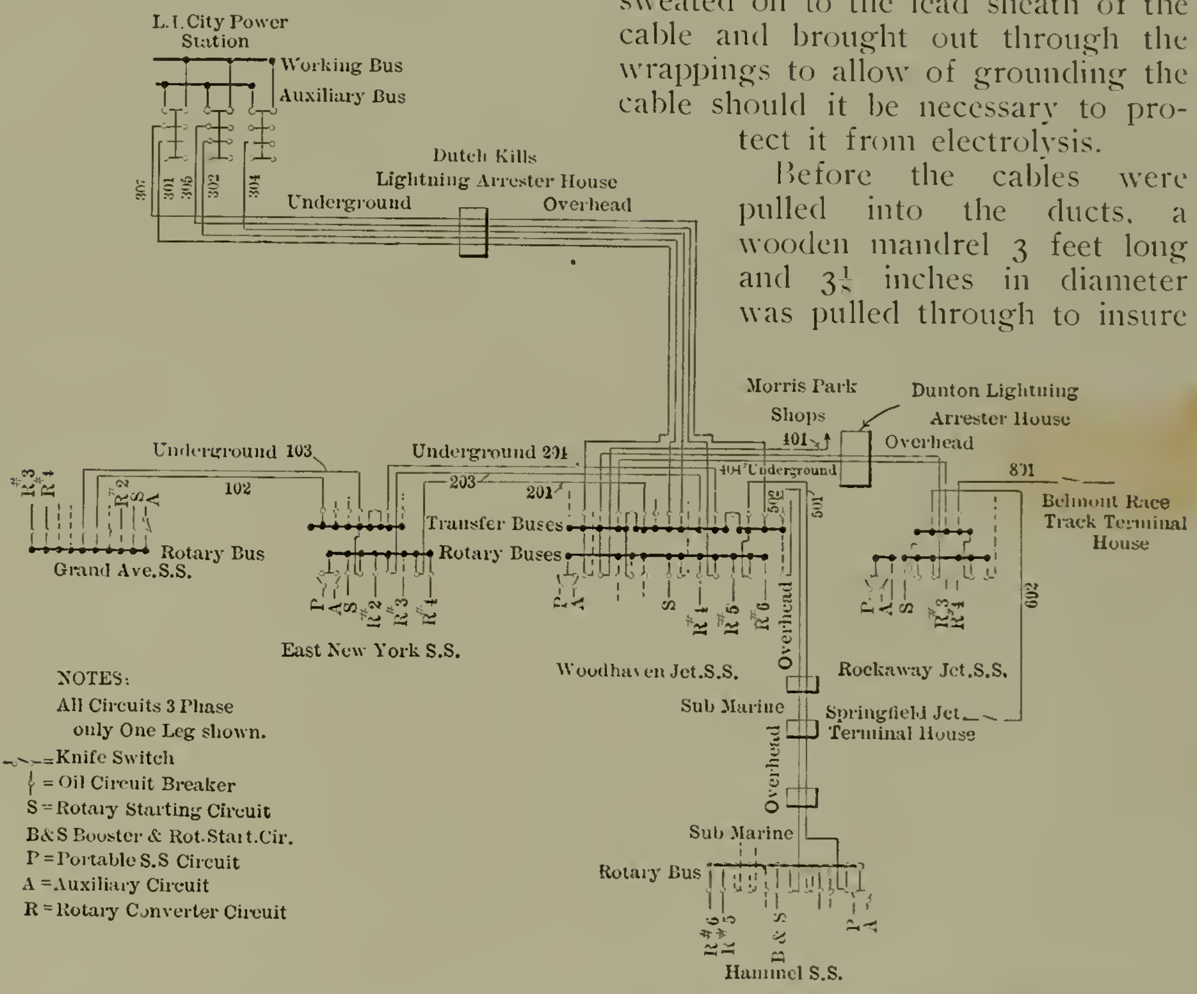


FIG. 3.—DIAGRAM SHOWING THE GENERAL ARRANGEMENT OF THE TRANSMISSION CIRCUITS

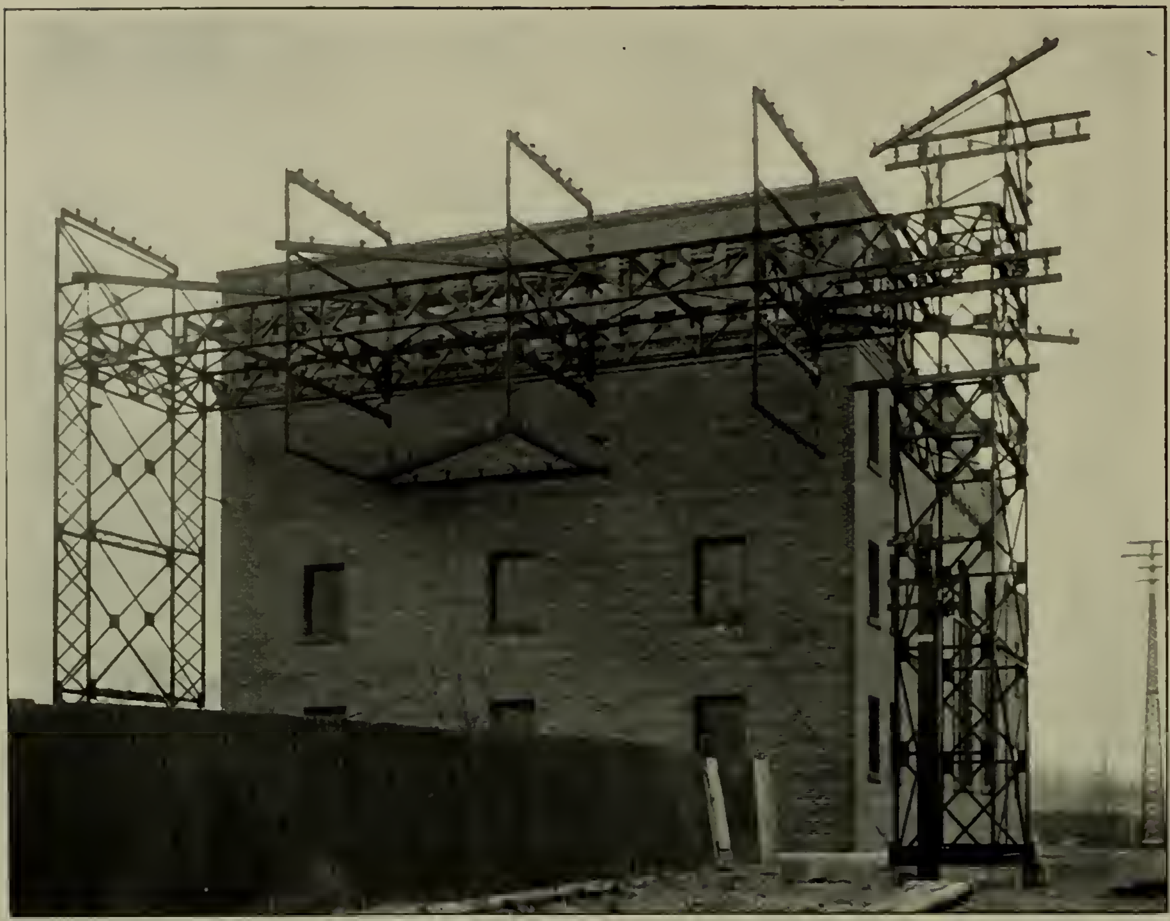


FIG. 4.—THE TERMINAL CABLE RACK AT THE ROCKAWAY JUNCTION SUB-STATION

vation, unless the cables should be laid during the dredging process, which is obviously impracticable.

There is in all about 25 miles of high-tension underground cable installed, besides 0.418 mile of armoured submarine cable.

ARRESTER HOUSES

The vulnerability of underground cables to lightning and to other static disturbances set up in the line require that the outlying ends of cables exposed to lightning discharges have protective apparatus.

Whenever the underground cable section of the transmission line is joined up with the overhead system, lightning arresters and choke coils are installed, and suitable houses are provided to shelter this apparatus. There is one on the main transmission ilne at Dutch Kills Street, Long Island City, and another at Dunton, on the branch line running east of Woodhaven. Smaller houses were also provided for the same purpose at the two drawbridges.

The house at Dutch Kills Street is a fireproof brick structure, with a concrete floor and roof; it is 33½ feet in length, 17½ feet wide, and 30½ feet high inside. This house at present contains room sufficient for eight outgoing overhead circuits which leave the house four on a side. The general design of the transmission line is such that the circuits on one side of the poles can be shut down for repairs without shutting down those on the other side, and this idea was carried out in the construction of the arrester house, so that there would be no confusion possible between live and dead conductors whenever it might become necessary to do any repair work on the line.

The arresters are all provided with knife switches, so that they can be readily disconnected from the circuit. A choke coil is also provided in series with each main circuit, and another knife switch between the choke coil and the cable bell, enabling the cable to be entirely disconnected from the overhead line.

The ground connections all run to a single ground lead consisting of 5½ square feet of copper plate buried in the ground between layers of crushed coke. The arresters are of the Westinghouse low equivalent type mounted on marble slabs, which in turn are carried upon porcelain insulators.

The outgoing cables on each side are anchored on a strain pole after leaving the racks upon the sides of the building, which in themselves are not intended to carry the longitudinal stresses of the overhead cables.

The openings in the side of the house through which the cables run are 18 inches square, enclosed by two glass plates ⅜ inch thick and separated 5 inches with 2½ inch holes in the centers, through which the cable passes without touching the glass. A thin disk of brass 2½ inches in diameter is attached to each wire midway between the glass plates, and thus prevents the direct access of rain or snow through the openings. Standard straight line insulators are used for supporting the bare wires inside of the building.

The arrester house at Dunton is shown in Fig. 2. Here the branch transmission line running eastward from Woodhaven is changed from conduit to overhead construction. The design of this house and the arrangements of the apparatus inside it are identical with the one just described, but with capacity for six circuits instead of eight.

At the drawbridge channels in Jamaica Bay, three houses are provided to shelter similar apparatus. Each consists of a steel framework covered with expanded metal and concrete side walls and a corrugated copper roof resting on a pile foundation.

OVERHEAD LINE CONSTRUCTION

There are two general divisions of the overhead construction,—the trunk line between Dutch Kills Street and Woodhaven Junction, and the branch lines between that point and the other outlying sub-stations. The trunk line is built of steel poles, and the branch line between Dunton and Rockaway Junction, through which the latter sub-station and two portable sub-stations are fed, and upon

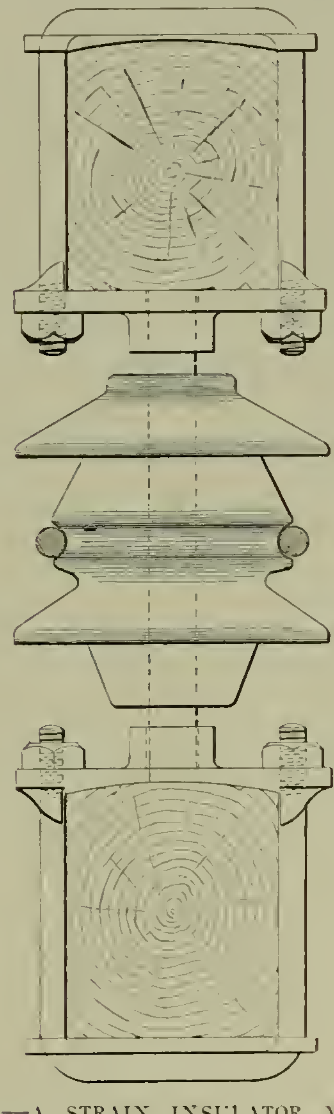


FIG. 5.—A STRAIN INSULATOR MANUFACTURED BY THE R. THOMAS & SONS COMPANY, EAST LIVERPOOL, OHIO

which the circuits to stations not yet constructed may eventually run, is also equally important with the trunk line and is therefore built of steel.

From Rockaway Junction, the branch pole lines to the separate outlying sub-stations are of wood. From Woodhaven Junction south, the poles are of steel to the southern outskirts of Ozone Park, because of the rather exceptional height at which the cables have to be carried to clear other wires, but from Ozone Park to Hammel they are of wood.

The trunk line is designed to carry eight three-phase transmission circuits consisting of three 250,000 c. m. cables each, together with eight low-tension cables of 500,000 c. m. each. As the latter when installed must be 25 feet above the ground, and as there must be a reasonably clear space between the low and the high-tension circuits, steel tower construction is necessarily used.

The branch line transmission circuits, however, are not intended to carry more than two three-phase transmission circuits and four low-tention cables on a single line of poles. This condition enabled the use of wooden poles, of which an extra heavy type was selected for stability

STEEL POLES

The steel poles are of various sizes to meet the different conditions. They are all designed to carry twenty-four 250,000 c. m. cables, on their upper portions, and underneath them an additional load of eight 500,000 c. m. low-tension cables, which local regulations require to be at least 25 feet above the ground. The spans between steel poles average 150 feet in length, except where turning corners or carrying the cables over railroad tracks. The poles are able to carry safely a weight of 4500 pounds of cable.

The steel poles are built of four corner angles connected together by angles and plates forming a lattice type of construction. They are tapered uniformly to the top on two sides and to within about 7½ feet of the top on the other two sides, the taper being ⅜ inch per foot. This taper is uniform to the bottom of the pole, and is the same for all lengths of poles. The tops are in every case 6 by 11 inches. At the bottom the corner angles are tied to a base composed of plates and channels through the corners of which the four anchor bolts pass. This forms a sort of box construction around the base of the pole and greatly increases its stiffness and stability.

The standard poles are made in four lengths, increasing by 5 feet, from 39 feet to 54 feet in length, the 39-foot pole being the standard, the other lengths being only used where necessary. On account of the previously mentioned uniform taper, the sizes of the bases vary from 3½ by 4 feet to 4½ by 5 feet, depending on the height of the pole. The foundations are therefore proportioned accordingly. The poles are designed to withstand a wind pressure at right angles to the line corresponding to a wind velocity of 100 miles per hour.

The design of the curve poles was made dependent on the distance by which the curve pole is offset from a straight line joining the two poles on either side of it. For offsets up to 6 feet, the corner angles of the pole construction are 3½ by 3 by 7-16 inches, while for offsets between 6 feet and 10 feet the corner angles are 3½ by 3 by ½ inch.

The strain poles used for anchorage are guyed fore and aft to the bases of the adjacent poles with 7-16-inch galvanized steel cable. On some sharp curves the poles were guyed laterally as an additional precaution, using 7-16-inch guy cable and Stombaugh guy anchors.

The construction of the steel pole includes angle iron seats for the cross arms which pass through the pole structure, the weight of the cables holding the cross-arms down on the seats and requiring only the simplest type of fastening, which consists of two ¾-inch "U" bolts, which clamp the cross-arms immovably to their seats. The use of the ordinary type of cross-arm brace is rendered unnecessary.

The ability of the steel pole to act as a lightning rod is turned to advantage, and each pole is thoroughly grounded to a copper plate buried beneath the foundation and connected to one of the anchor bolts by a copper wire.

WOODEN POLES

Chestnut poles were used for ordinary work and creosoted yellow pine along the trestle over Jamaica Bay. The chestnut poles are 45, 50 and 55 feet in length, and 25 inches in circumference at the top. The creosoted poles are from 60 to 80 feet long, with the same dimensions at the top, and treated with 15 pounds of dead oil of coal tar per cubic foot of timber. Creosoted poles are all set 15 feet into the bottom of the bay by means of a water jet, and have their tops 30 feet above the rails.

The total number of steel poles employed is 377, of chestnut poles, 490, and of creosoted yellow pine poles, 264.

CROSS-ARMS

The cross-arms are of yellow pine, 5 by 6 inches in cross-section, housed on top to a 12-inch radius, and painted with one coat of asphaltum paint.

FIG. 6.—THE INSULATORS WERE MANUFACTURED BY THE R. THOMAS & SONS COMPANY. THE PINS ARE CLAMPED TO THE CROSS-ARMS, AS SHOWN HERE

On the wooden poles they are gained one inch into the pole and held by one ¾-inch through bolt with 2-inch square washers. Bracing, though unnecessary on the steel poles, was effected in the case of wooden poles by angle iron braces made in one piece and bent V-shape. For standard steel poles the arms are 7 and 9

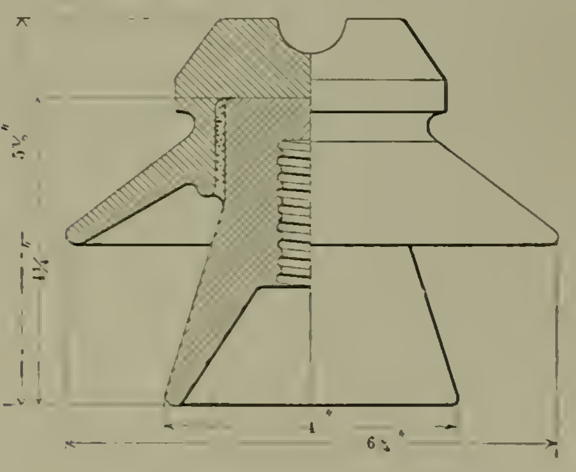


FIG. 7.—A SECTIONAL VIEW OF THE INSULATOR SHOWN ABOVE

feet long. For steel strain poles they are 7 feet 10 inches and 10 feet 6 inches.

On the steel pole line, the apex of the triangle, at the points of which the wires are carried, is placed on top, while on wooden pole portions of the line the apex is at the bottom. The

FIG. 8.—VIEW NEAR JAMAICA STATION, SHOWING THE THIRD RAIL AT AN INTERLOCKING JOINT

latter position is that generally preferred for the arrangement of high-tension circuits, as it allows repair men more easily to get up between the circuits. On the trunk line, however, the necessity for carrying the maximum number of circuits made it desirable to reverse the usual order and the apex was accordingly placed on top.

PINS

The insulator pins consist of malleable iron castings clamped to the cross-arms by means of U-bolts threaded through the body of the pin, and held by a plate fitting over the U-bolts and against the cross-arm as shown in Fig. 6. This type was first used on this transmission line and represents a new departure in pin design, inasmuch as by its use all boring of the cross-arm is avoided. The strength of the cross-arm is maintained, and the depreciation resulting from entrance of moisture through holes bored in the arm from top to bottom, is obviated.

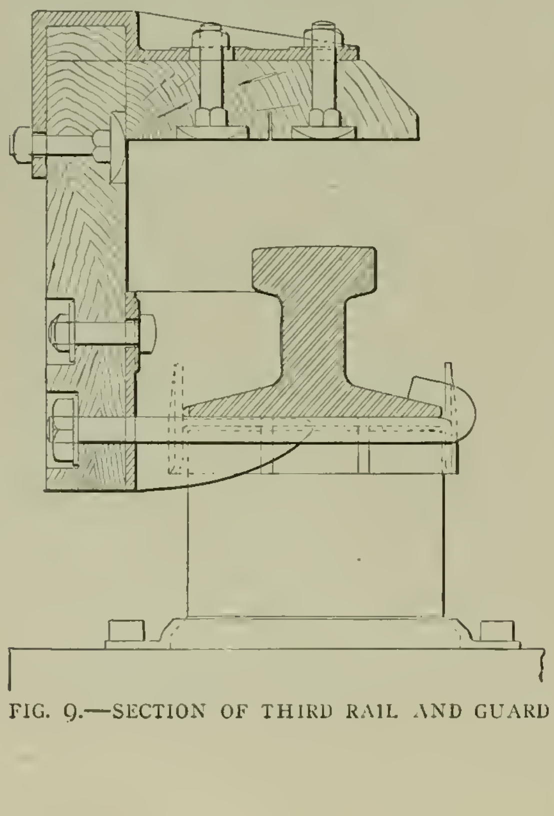


FIG. 9.—SECTION OF THIRD RAIL AND GUARD

This pin is also of much greater strength than is possessed by one in which the bending moment where it enters the arm has to be met by a small cylindrical cross-section, which in case of the iron pin is sometimes not more than ¾-inch in diameter, and in a wooden pin 1½ inches to 2 inches. The strongest part of this pin is at the base where it joins the cross-arm. It admits of easily following up of any shrinkage of the cross-arm. All that is necessary, if the pin comes loose, is to tighten up the nuts on the under side of the clevis.

INSULATORS

The straight line insulators are 6½ inches in diameter and 5 inches high. They are made of porcelain in two parts connected together. The insulators are coloured with a brown glaze to render them less conspicuous. They are designed particularly for the conditions here imposed. The pin and insulator together carry a 250,000 c. m. cable 6½ inches above the cross-arm. The ties are made of ordinary soft copper wire, tied on top.

The tests to which the insulators were subjected at the factory include a rain test at 30,000 volts and a salt water flash test of 50,000 volts for two minutes. The insulators were further obliged to pass the test of plunging them into hot water and then into ice water without cracking. After the insulators were erected and the cables strung upon them ready for operation, they were tested by applying 30,000 volts between the conductor and the ground for four minutes. The insulators underwent all these tests successfully.

The strain insulators are of the "spool" type and are made in one piece 7½ inches in diameter and 8 inches high. Each strain insulator has two petticoats, one above and one below the point where the wire is attached.

The insulators were cemented onto the pins before erection. The cement used throughout was composed of litharge moistened with a mixture of glycerine and water. This type of cement was found after careful trials to be preferable to Portland cement, and, although the materials were more expensive, the labour cost of the cementing and the risk of breakage more than counterbalanced the extra cost of material. The steel bolts that held the pins upon the strain insulators were cemented in the same manner. The pin was first wrapped with lead foil to prevent cracking due to possible expansion of the pin.

CABLES

The transmission cables are of 250,000 c.m. stranded copper and are fastened to the insulators with ties of No. 6 copper wire 3 feet long. Splices were made by cutting back the core of the cable and wrapping the outer layers of strands around the abutting cables, after the manner of the ordinary Western Union splice. All the joints were soldered. Where jumpers were used to lead into sub-stations or arrester houses the ordinary half connection joint was made and carefully soldered. The total amount of overhead transmission cable erected is 62.03 circuit miles, or 186.09 miles of cable.

No low-tension cables were required for the initial installation except to connect up isolated sections of third rail, where it became necessary to break the third rail at switches and crossings. There are, therefore, no low-tension cables on the poles at present, but when installed they will be carried upon heavy porcelain top groove insulators and pins of the same general type as previously described.

Wherever the power transmission circuits cross the highways or railroad tracks, special precautions are taken to insure against the possibility of a cable falling off a cross-arm and hanging down in position to endanger passing traffic. At such points the spans are shortened as much as possible. In some cases an extra straight line pole is used in the line, and at other points a strain pole is placed on each side.

Wherever the wires cross other electric circuits the high-tension wires are carried above the others, as their large size and strong mechanical supports make them less liable to fall upon others than would be the case if their positions were reversed. At all crossings and over station platforms and on the inside of curves, vertical angle irons, called "retainers," are bolted to the ends of the cross-arms, so that in case of the insulator breaking or cross-arm burning off, the wire cannot fall any distance away from its normal position. Fig. 1 shows the retainers in position on a pole carrying the trunk line over the tracks near Glendale Junction.

TERMINAL CABLE RACKS

At the Woodhaven and Rockaway Junction sub-stations special terminal poles or racks are provided to distribute the overhead circuits along the face of the building parallel to the high-tension switching galleries in such a manner that the disposition of the cables after entering the building will be most convenient.

The sub-station galleries were laid out for the most convenient subdivision of the high-tension bus into sections for distributing power to the branch feeder circuits. An idea of the manner in which this was accomplished may be had from Fig. 4, which shows the terminal pole at Rockaway Junction.

The wires of the circuits as they come from the trunk lines are brought in at the same plane, the upper circuits going to the top cross-arm, which is located at the rear or farthest end of the terminal pole. The next lower circuits are anchored directly in front of these, and so on, gradually working toward the front of the pole and downward from the top of the pole, as one circuit after another is added, thus obviating interference with working circuits when new ones are being erected. By an arrangement of jumpers the outside circuits are led around without interfering with other circuits and are brought opposite their proper pigeon holes in the side of the sub-station structure.

The terminal racks at both stations consist of steel truss bridges about 11 feet wide and practically as long as the side of the sub-station building. They are supported on lattice steel columns, which are carried on concrete foundations. The wires are supported on standard insulators, which are carried on the regular type of cross-arms sawed long enough to project over both sides of the truss, to which they are fastened by U-bolts, as they are on the standard poles. Where the cables are dead-ended they are fastened to the strain type of insulator, which is mounted in the manner before described.

THIRD RAIL CONSTRUCTION.

A study of the equipment clearances pointed to the necessity of locating the third rail with its gauge line 26 inches inside of the gauge line of the running rail, and its top at a height of 3½ inches above the top of the track rail. After considering a great variety of designs, both of rails and contact shoes, it was decided to adopt the top contact type, with a horizontal guard extending directly over the rail, requiring the use of the slipper type of contact shoe, as shown in Fig. 9.

The rail used for most of the construction has a modified tee shape and weighs 100 pounds to the yard in 33-foot lengths. The section is 4 inches high, with a head 3 inches wide, bottom flange 6 inches wide, and web 1½ inches thick. This particular shape was selected because of the limited vertical distance between contact and running rail tops, requiring that the upper rail be of as low section as possible to provide maximum insulation distance to tie.

All of the main line tracks on the elevated line are provided with this 100-pound third rail, excepting about 7½ miles, which are fitted with 70-pound standard relaying T-rails. For side tracking and unimportant spur work 60-pound relaying rails were used.

The contact rail is supported every 10 feet on vitrified clay insulators. Resting on top of the insulator is a malleable iron cap, which projects down over it for a distance of 1¼ inches and has two ears 1¼ inches long projecting upwards. The rail rests on top of the cap between the ears. With this type of insulator no vertical strain comes upon it due to the sagging of the tie when a train passes, as the rail is in no way directly attached to it. The design also facilitates the removal of broken insulators, as the whole device may be removed by taking out two lag screws in the base.

The third rail joints are bonded by laminated copper foot bonds with plug terminals. They vary in size according to the weight of the rail to which they are applied, 300,000, 350,000 and 400,000 c.m. sizes being employed. The holes for the plug terminals were punched in the base of the rail by hydraulic punches, and the terminals were riveted into the holes by hydraulic compressors.

CABLE JUMPER CONSTRUCTION

The third rail is frequently interrupted by highway crossings and switches, and at such places underground cables are provided to maintain its electrical continuity.

As at present installed the third rail system is not fed in separate sections from the sub-stations, but is treated as a continuous conductor between sub-stations, except where the number of switches and cross-overs incidental to a station terminal or junction necessitates dividing it into sections that can be easily isolated from the remainder of the third rail should emergency require. There are, therefore, no low-tension cables running along the tracks to reinforce points distant from the sub-stations, but the frequency of highway grade crossings and track switches and cross-overs requires the frequent interruption of the third rail. To maintain its electrical continuity at such places underground jumper cables are provided.

THIRD RAIL GUARD

The Stilwell-Slater type of guard was adopted for the third rail. It consists of yellow pine plank 1¾ inches thick, 7 inches wide, placed above the rail, with 2½ inches clear space between the top of the rail and the under side of the plank. The edge of the plank nearest the track extends ¾ inch beyond the line of the third rail head and is beveled back to give the necessary clearance for running equipment. Each plank has a saw cut ¾ inch deep in the middle of the under side to prevent warping. The planks vary in length from 14 to 16 feet. The guard is supported directly from the third rail, there being four supports to each plank. The planks are butted together without splicing, so as not to interfere with the free expansion and contraction of the rail and to facilitate repairs. Fig. 9 shows the guard in detail.

All the timber guards are painted with two coats of a good quality of weatherproof paint. Experience up to the present time leads to the belief that the guard will prevent most of the troubles that commonly arise from sleet.

DRAWBRIDGE CONNECTIONS

At the drawbridges in the Jamaica Bay trestle the third rail is interrupted, and to maintain this continuity three submarine cables are installed, one for each third rail, and one extra cable. These cables consist of 2,000,000 c.m. copper core insulated with 4-32 inch of 30 per cent. Para rubber incased in a lead sheath $\frac{1}{8}$ inch thick and armoured with one layer of No. 4 B. & S. galvanized steel wires laid on spirally with a layer of jute covering. These cables were laid in the same manner as the high-tension power transmission cables which have already been described.

The short length of third rail on the drawbridge is connected by brass contact shoes, which make connections at each end of the draw when it is closed.

SYSTEM OF THIRD RAIL CONNECTIONS

The cables connecting the third rail with the sub-stations are all of 2,000,000 c.m., and connections are made directly in front of the sub-stations. In some cases these short feeders are located in conduit and in other cases laid directly in the ground in the manner described for the crossing jumpers. Such cables when laid in ducts are insulated with 5-32 inch of paper, covered with a layer of sheathing $\frac{1}{8}$ inch thick.

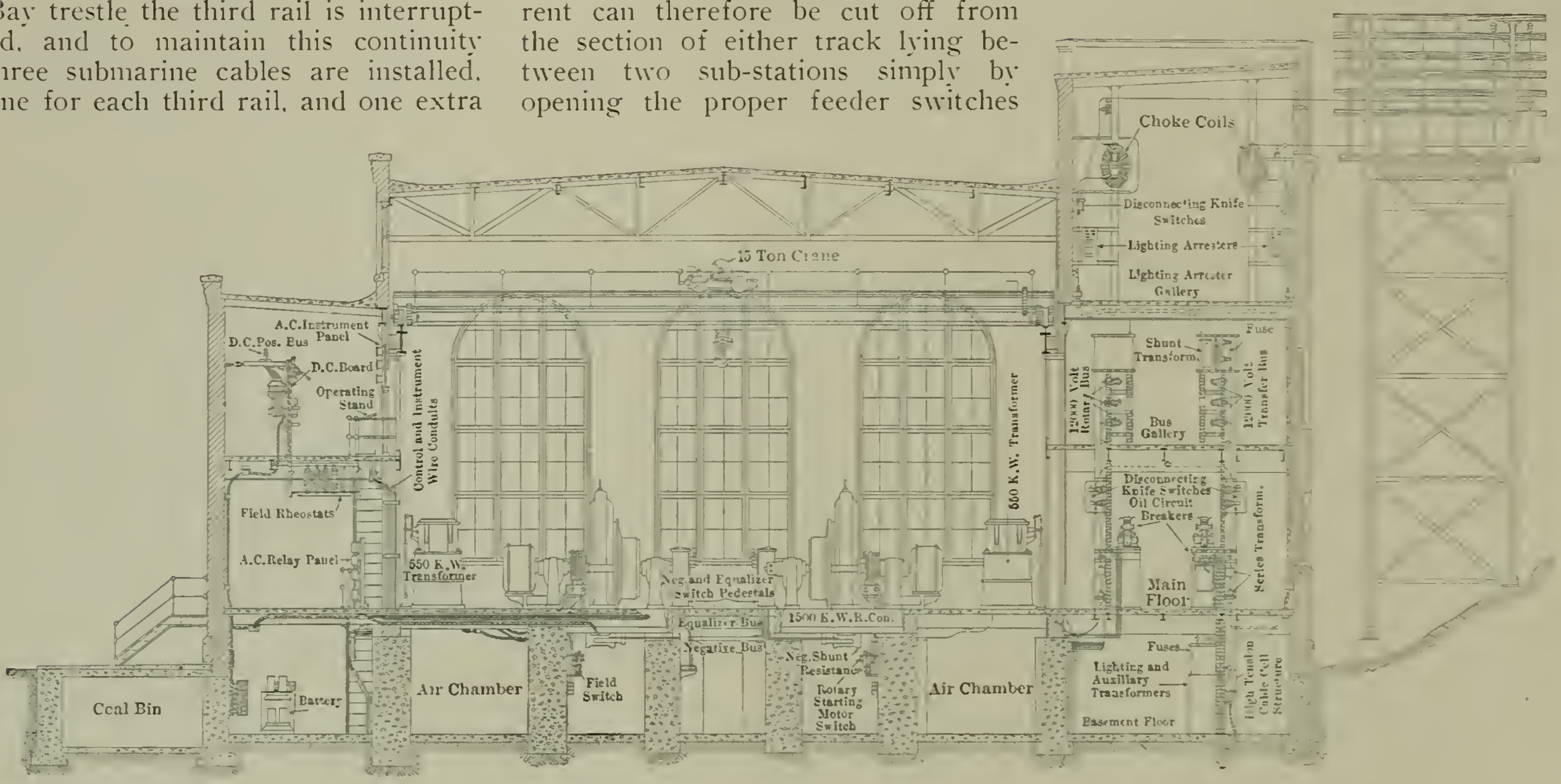


FIG. 10.—SECTIONAL ELEVATION OF THE SUB-STATION AT WOODHAVEN JUNCTION

Near each sub-station the third rail is interrupted by a 40-foot gap. Should any section break down it is then impossible for a single car to bridge the gap between the live rail and the grounded one, thus avoiding the possibility of injury to the car wiring and equipment. The east and west bound tracks are in most cases supplied by a separate set of feeders and are not cross-connected except through the station bus-bars. Current can therefore be cut off from the section of either track lying between two sub-stations simply by opening the proper feeder switches in the stations at each end of the section.

In order that part of a section between two sub-stations may be disconnected in case of emergency, instead of requiring the whole section to be thrown out of service, 1,600-ampere disconnecting switches are installed at suitable intervals between sub-stations, being cut into the third rail circuit so that by opening any two of them the section between them can be cut out, though normally these switches are kept closed.

Practically all the line is double-tracked, excepting two stretches, which are four-tracked, one on Atlantic Avenue, between Chestnut Street and Woodhaven Junction, and the other running south from Woodhaven Junction as far as the north end of the trestle.

The only place where the east and west bound tracks are connected together occurs at the entrance to the yards, at the Rockaway Park terminal, at Jamaica Station and at the north end of Jamaica Bay trestle. At these points the two tracks are tied together by a 2000-ampere switch and circuit breaker, mounted under shelter and conveniently located, by means of which they can be separated when necessary.

Fig. 8 shows the arrangement of the third rail at a rather complicated interlocking point just east of Jamaica Station. The main third rail circuits are carried around this section by separate cables which run through a small switch house standing beside the tracks, in which is located the switch and fuse board.

RETURN CIRCUIT

Both running rails of each track are used for the return circuit. On a considerable portion of the line an automatic block signal system is used, requiring both running rails for its operation, so that a special method had to be employed in order to allow the tracks to be used jointly as a power return circuit and for signal purposes. The signal system was developed by The Union Switch & Signal Company, of Swissvale, Pa., and employs alternating current for the operation of the signals. With the aid of a special arrangement of bonding, the track is used for carrying both direct and alternating current without the former affecting the latter.

Where the automatic block signal system is used it is not possible to cross bond the running rails on account of the disturbance in the signal system which would thereby result. The cross connections only occur at the end of the signal blocks, where the special inductive bonds are cut into each track rail. These inductive bonds serve to keep out signal current, but for the direct current act exactly the same as the ordinary bond and maintain the continuity of the running rail. The cross connections between the tracks are made at these points, the inductive bonds being used in both tracks, so that the signal system is not affected by the flow of current between them.

The feeder connections between the track rail and the negative bus bar connections in the sub-stations are 2,000,000 c.m. bare tinned copper cable. In some cases these cables are buried directly in the ground without protection, while at others they run in vitrified clay ducts.

SUB-STATIONS

The principal feature of each sub-station is its equipment of rotary converters and transformers. In a single instance, namely, at Hammel, a storage battery was installed as an adjunct to the sub-station machinery. The location and arrangement of all the sub-station buildings is such as to enable the ultimate use of a storage battery should future conditions justify it, and the apparatus in each building is so laid out that if the storage battery should be installed the necessary boosters can occupy the space allotted to one rotary converter.

The sub-station equipment also includes two portable sub-stations, each consisting of a car containing one 1000-KW. rotary converter, three 375-KW. transformers, and the necessary blower and switchboard panels, high-tension oil circuit breaker, and connecting leads to the outside circuit breakers.

A storage battery was installed at Hammel, which is further from the power station than any of the other sub-stations, and, by reason of the exposed position of the transmission line running across Jamaica Bay, might be considered somewhat more liable to interruption in service through accident to the transmission. The marked fluctuations in load at this point, due to heavy travel to Rockaway Beach on summer afternoons and evenings, afford a better opportunity than almost any other location for testing the general applicability of the battery. The fact that the station load in the winter time is extremely light enables it to be operated for much of the time at this season from the battery alone, with the minimum cost of sub-station attendance during the greater part of the year. The storage battery equipment consists of 300 cells of 3200 ampere-hours capacity, and two boosters of 162-KW. capacity each.

FIG. 11.—IN THE SUB-STATION AT HAMMEL, 300 CELLS OF 3200 AMPERE-HOURS CAPACITY ARE INSTALLED WITH TWO 162-KW. BOOSTERS TO TAKE CARE OF THE LOAD FLUCTUATIONS ON THE ROCKAWAY BEACH LINE

SUB-STATION BUILDINGS

The buildings vary in height, due to the presence of overhead high-tension circuits. Where underground circuits only are used, as is the case at East New York and at Hammel, there are but two floors in the high-tension gallery. At Woodhaven and Rockaway Junction, however, where overhead circuits are employed, a third story is added to the high-tension gallery, which serves the double purpose of affording a convenient entrance to the building for the cables, about on a level with the cross-arms, and at the same time provides a suitable chamber for enclosing the high-tension lightning arrester apparatus.

Each sub-station is served by a 16-ton Niles crane, hand operated from its trolley, thus obviating the usual hanging chains. It spans the

FIG. 12.—AN INTERIOR VIEW OF PART OF THE SUB-STATION AT WOODHAVEN JUNCTION LOOKING TOWARD THE HIGH-TENSION GALLERY

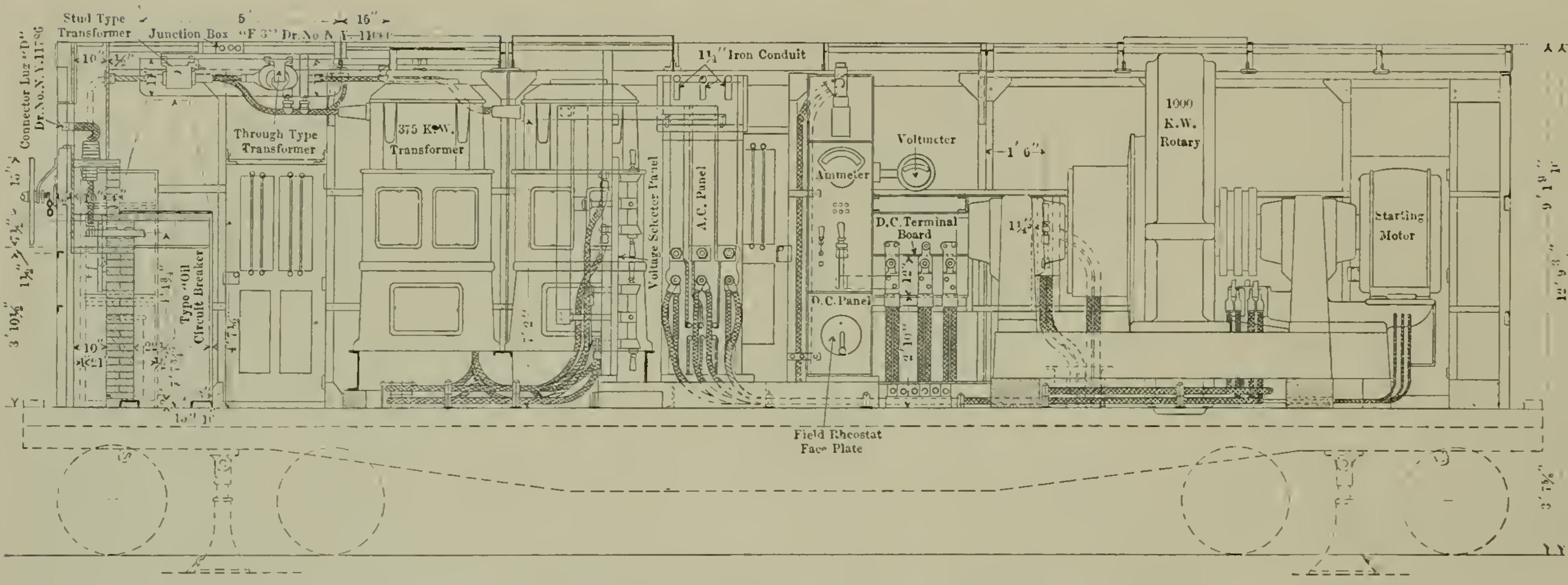


FIG. 13.—SECTIONAL ELEVATION OF A SUB-STATION CAR, SHOWING ARRANGMENT OF THE EQUIPMENT

central bay and is available not only for handling the permanent heavy sub-station machinery, but also the apparatus of the portable sub-stations which, excepting at Grand Avenue, can be run under it upon a track that enters one of the end-bays of the building.

Fig. 10 shows a complete sectional elevation of the sub-station at Woodhaven Junction, and Fig. 12 is an interior view of this station looking toward the high-tension gallery. The building is provided with a track entrance for the portable sub-station. It stands on railway property of sufficient size to accommodate a battery house immediately in its rear, should one ever become necessary.

ROTARY CONVERTERS

The rotary converters are of the two-bearing type, with field frames divided in a horizontal plane. Each converter is provided with a starting motor, whose frame is mounted upon an extension of the base of the rotary converter. The base frame is set into the floor so that the top of it is level with the floor line. It is entirely open below the commutator so that there is easy access to the lower brushes from the pit in the interior of the foundatiion, which can be easily reached from the basement.

The 1000-KW. rotaries, three of which are installed in the sub-stations at Grand Avenue and at East New York, and two at Rockaway Junction and at Hammel, are rated to deliver 1600 amperes at 625 volts, and 1667 amperes at 600 volts. The three-phase potential at the alternating-current end is approximately 370 volts, for 625 volts at the direct-current end. These machines have eight poles and operate at 375 revolutions per minute, corresponding to a frequency of 25 cycles per second.

The three 1500-KW. rotaries at Woodhaven Junction are rated to deliver 2400 amperes at 625 volts, or 2500 amperes at 600 volts. They have twelve poles and run at 250 revolutions per minute.

In nearly all respects the two sizes of machine are very similar. The fields are compound wound with the shunt winding arranged for self-excitation. The machines are so overcompounded, that if operated as direct-current generators at constant speed, the voltage will rise from 600 volts at no load to 650 at full load. The laminated steel pole pieces are beveled at the edges, and slotted through the faces to allow the use of massive copper dampers of the grid-iron type, which pass through and around the pole faces. The synchronizing power is thereby increased and hunting prevented.

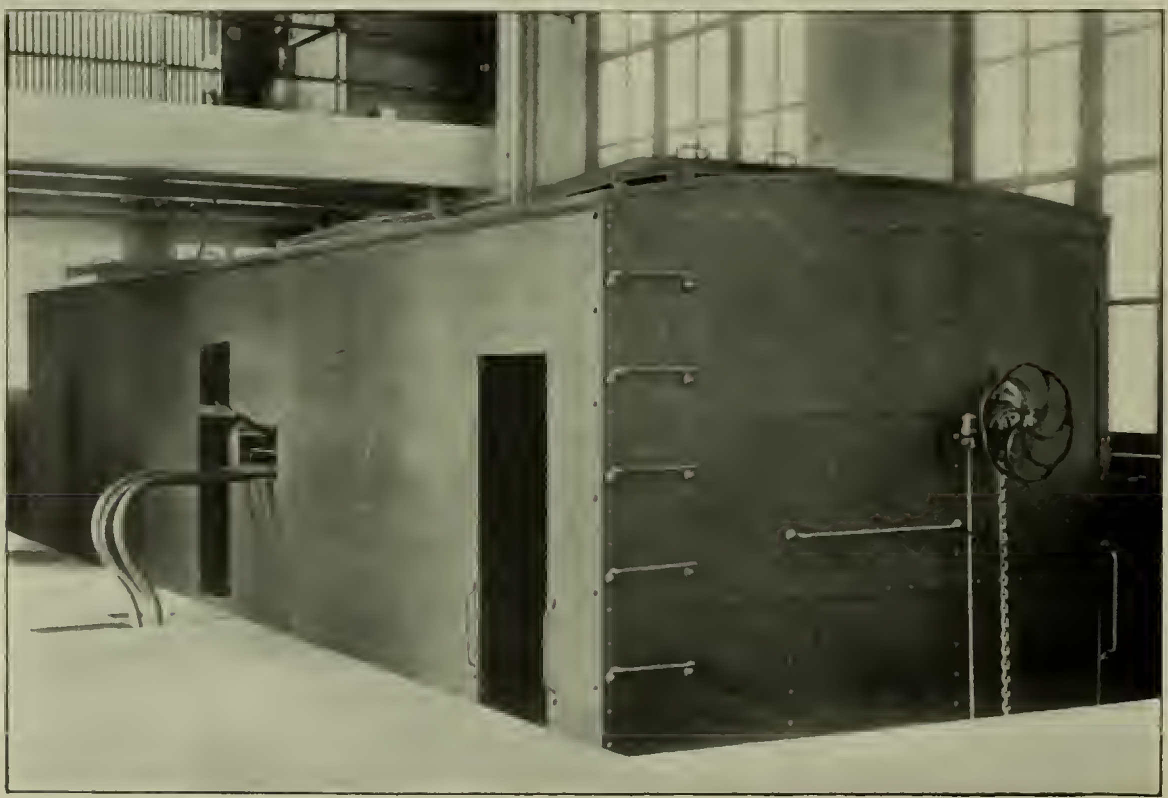


FIG. 14.—A SUB-STATION CAR CONNECTED UP IN THE INTERIOR OF A PERMANENT SUB-STATION. THE CAR IS BUILT OF STEEL AND RESEMBLES A FREIGT CAR IN APPEARANCE

TRANSFORMERS

The transformers used with the converters are of the air-blast type throughout. Those for the 1000-KW. rotary converters are grouped in banks of three 375-KW. transformers to one rotary converter. For the 1500-KW. converters they are in groups of three 550 KW. each.

The high-tension winding is designed for a normal electromotive force of 12,000 volts with taps arranged to enable other voltages to be utilized down to 10,000 volts. The low-tension winding is designed to normally carry 400 volts with taps which will enable other voltages to be taken off it down to 340 volts.

AUXILIARY TRANSFORMERS

In each station there are four sets of auxiliary transformers which supply current for the following purposes:—

1. To the rotary converter starting motors.

2. To the motors driving the booster generators and their exciters. At Hammel station these transformers are made large enough to also drive rotary starting motors at the same time.

3. For driving the transformer blower motors, and an induction motor-generator set used to charge the small auxiliary storage battery that supplies current for the electric switch control system.

4. For house lighting.

HIGH-TENSION BUS-BARS AND CIRCUIT BREAKERS

The sectional elevation at Woodhaven Junction sub-station, Fig. 10, shows the high-tension cables entering through the lightning arrester gallery in the third story. The cables extend down the wall into the basement and run first to the proper oil switch, and thence up to the transfer bus in the gallery overhead, each cable being in a separate brick septum. The outgoing branch circuits are tapped out of the transfer bus, each tap coming down a septum in the back wall of the bus structure to the oil switch directly underneath.

Between every oil switch and the bus to which it is connected is a set of three disconnecting knife switches, one in each phase. Their function is to completely isolate the circuit breaker from the bus-bars, and to facilitate inspection, cleaning and repairs. Two of the outgoing branch circuits emerge underground, while the third leaves by the overhead route.

HIGH-TENSION SWITCHES

The switches for manipulating the 12,000-volt current for the feeders, and for the leads to the main transformers, are Westinghouse oil circuit breakers.

They are all three-pole, with two stationary contacts per pole, one for the incoming and the other for the outgoing lead of the same phase. Each pole of the oil circuit breaker is enclosed in a separate fireproof chamber of brick, capped with a slab of alberene stone upon which the operating gear is mounted.

Both automatic and non-automatic circuit breakers are employed. They are all automatic except those used for connecting the sections of the transfer bus, and for connecting the two transfer buses to the rotary bus. The switches controlling feeders that pass through a station, and also those which control apparatus supplied from the rotary bus, are all automatic.

PORTABLE SUB-STATIONS

Two portable sub-stations were provided, each consisting of a 1000-KW. rotary converter with transformers, switchboard apparatus and the necessary auxiliaries, carried in a heavy steel car resembling a freight car in general appearance. A sectional elevation of this sub-station car is given in Fig. 13, which shows the disposition of the apparatus.

The end of the car containing the rotary converter is so built that it can be readily taken to pieces, and in fact, entirely knocked down so that the rotary converter can be easily taken apart if necessary, by being run under the crane in any of the sub-stations.

Besides the rotary converter, which is identical with the previously described standard rotary converters of 1000-KW. capacity, are three 375-KW. transformers of the air-blast type, fitted with blower and motor. The apparatus can perhaps be best described by following the course of the current through it.

The high-tension connections enter through an opening in one end of the car, which, when not in use, is closed by a steel flap hinged so as to fall directly over the aperture. The three connections for the three-phase current are tapped directly to lugs that project through the rear of the oil switch structure. The oil switch is of 600 amperes capacity, three pole, and electrically operated. Just before entering the oil switch, taps are taken off for two potential transformers, both of them being used for the wattmeter connections, and one of them being used as the line side of the synchronizing apparatus.

After leaving the oil switch, the main connections pass through series transformers, from which run connections for the integrating wattmeter. The main connections then run directly to the main transformers, where they fasten to the terminals of the high-tension coils. On the low-tension side of the main transformers, four connections are made between each transformer and a transformer terminal panel. These four taps are arranged so as to give four different voltages for the rotary converter, as on such a large system as this it is quite likely that the voltage at different sub-station points may vary from time to time under different conditions. This transformer terminal panel is provided with several switches making possible four combinations of voltage.

The main alternating connections then run directly to the alternating-current rotary converter panel through heavy bus-bars extending up past the top of the panels. On the main alternating-current panel, taps are taken off for the rotary starting motor, and also for the synchronizing transformer on the machine side. From this panel the main cables run direct to the alternating-current side of the rotary converter.

The portable sub-station rotaries are synchronized from the low-tension side, by means of a synchroscope. That is, the rotary converter is started up by the starting motor after the transformers have been cut in, and by the aid of a synchroscope the low-tension alternating-current switches on the rotary panel are thrown in by hand at the instant of synchronism.

From the direct-current side of the rotary, the negative connection runs direct to a lug, mounted on a slab, placed conveniently at the side of the car, opposite the opening, through which connections are made to the fixed lugs in either the portable sub-station house or in the permanent sub-station. There is no switch in this connection. The equalizer is also taken from the negative pole of the machine and run to an equalizer switch mounted on the inside of the car, conveniently to the slab supporting the outgoing lugs, whence a connection can be made to the other portable sub-station if it is in the same house, or to the equalizer bus of the permanent sub-station if that is where the portable sub-station happens to be working.

The positive leg goes to a direct-current panel in the car, which carries a single 2000-ampere switch, with 3000-ampere ammeter and circuit breaker. From the circuit breaker a connection is led to the slab where the taps are made to whatever third-rail circuits the portable sub-station is connected. Fig. 14 shows one of the portable sub-station cars connected up in the interior of a permanent sub-station.

SUB-STATION HEATING AND LIGHTING EQUIPMENTS

Each sub-station is fitted with a hot-water heating system supplied from a boiler in the basement. The lighting is accomplished through a transformer which supplies a 105-volt three-wire lighting bus. Ten lighting circuits are distributed from fuse slabs carried on the back of a separate marble panel, and there are ten switches for the accommodation of the various lighting circuits that run about the building. Both 16-

candle-power incandescent lamps and 4-glower Nernst lamps are used.

TRANSFORMER BLOWER OUTFIT

As the main transformers in these sub-stations are all of the air-blast type, electric driven blowers are provided to furnish the necessary draft. They are in two sizes, and are operated at 480 revolutions per minute by motors of 9.8 H. P. and 6.6 H. P., respectively. The motors are coupled direct to the fans, and are of the three-phase induction type operating at 400 volts from auxiliary transformers.

SIGNAL SERVICE APPARATUS

The railroad lines are protected by a block signal system specially devised to work with alternating current, by which means it becomes possible to make use of the well-known feature of short circuiting the two rails of the track without requiring that one of them shall be devoted only to signaling purposes, which would cut down by one-half the capacity of the track return circuit.

Accordingly, a set of transformers is placed in the Woodhaven Junction sub-station, there being two of 100 KW. each, one only being in service, the other being a spare set. These take 11,000-volt current, single-phase, and transform it to 2200-volt current for use in the signal system. The transformers are located in the basement and are supplied through a type B, 11,000-volt oil switch mounted on a separate marble panel.

AIR CLEANING SETS

At each sub-station there is provided a motor-driven air compressor, the motors of which are wound for 600 volts, direct current. Their capacity is 60 cubic feet of free air per minute, up to 100 pounds pressure. The motor is geared to the compressor. The compressor supplies a system of air piping running to outlets conveniently placed for blowing air into the rotary converters and the switching apparatus for cleaning.

CONCLUSION

The completed overhead line was first put in service April 27, 1905, and the third rail was first put in service about May 13, 1905. Regular operation began July 26, 1905.

The sub-stations were first supplied with high-tension current from the overhead lines, and tested out on April 27, 1905. Current was first furnished from Woodhaven Junction to the third rail for car tests May 13, 1905. The portable sub-stations were first placed in operation June 12, 1905.

The operation of the transmission line and the third rail have been remarkably free from interruption of any kind, and has demonstrated their efficiency as a substantial and reliable transmission system for a suburban railroad, on whose regularity of operation thousands of people are daily dependent.

The design and construction of the entire transmission and sub-station system were carried out by Westinghouse, Church, Kerr & Company, engineers for the Long Island Railroad Company, and the entire work was under the direction of Mr. George Gibbs, chief engineer of electric traction of the Long Island Railroad, subject to the approval of an electric committee consisting of the chief operating officials of the road, with the president as chairman.

Electricity on the New Hamburg-American Liner "Kaiserin Auguste Victoria"

THE Hamburg-American Line steamer "Kaiserin Auguste Victoria," the largest passenger steamer yet built, is well equipped electrically, six generating sets, of a total capacity of 445 KW. being provided to supply current for lighting, heating and other purposes.

A telephone system is, of course, provided, and by this means communication is had between all the first-cabin staterooms on the promenade decks and the Crown Prince deck, as well as the saloons, the entries of the other first-cabin staterooms and the pantry. Six telephone central stations are provided for the first cabin and one for the second cabin. A loud-speaking telephone system also connects the bridge with both engine rooms, the engineer's office, the telephone house aft, the crow's nest, the lower bridge, the wheel house and the stern. Three signal systems are provided:—An alarm bell signal system for the ship and engines; a bell signal system for fire extinguishing purposes; and a fire-alarm system with annunciators on every deck.

A Marconi wireless telegraph installation makes possible the sending and receiving of messages while at sea, and also the reception of news for two daily newspapers which are printed on board, one in German, called the "Atlantisches Tageblatt," and the other in English, "The Atlantic Daily News."

Electrical heating devices are used quite extensively. In the first and second-cabin staterooms electric curling-iron heaters and food warmers are provided by which milk, coffee, and the like may be kept warm during the night. All the apartments and staterooms, except the smoking room, are heated electrically.

In the electric bath the heat of incandescent lamps is employed to produce the same effect as that of a Turkish bath. The bath consists of an octagonal cabinet in the centre of which is a stool. Two sides swing out as doors, and a circular opening is left in the top, the head alone protruding.

In the kitchen, the plate washers, knife cleaners, and silver-cleaning machines are electrically operated, and electrical egg boilers are also used.

An electric passenger elevator runs through five decks, and for handling provisions electric elevators connect the provision room with the kitchens.

Perhaps the most novel thing on the ship is the gymnasium, provided for the use of the first-cabin passengers. The various pieces of apparatus are designed according to the Swedish Zander system, and are motor-driven.

One convenience which is much appreciated by the male passengers is the electric cigar lighters placed in the smoking rooms of the first and second cabins and in the restaurant.

Census of Manufacturers of Electrical Machinery and Apparatus

THE result of the tabulation of statistics of electrical machinery and apparatus recently given out by the Director of the Census contains the following comparative figures for 1905 and 1900:—

	1905	1900	Per Ct. of Increase
Number of establishments	782	580	35.9
Capital	$191,469,874	$83,130,943	130.3
Salaried officials clerks, etc.:			
Number	11,590	4,987	132.4
Salaries	$11,675,576	$4,563,112	155.9
Wage earners:			
Average number	59,336	40,890	45.1
Wages	$31,226,721	$20,190,344	54.7
Miscellaneous expenses	17,934,878	6,788,314	164.2
Total cost of materials used	66,728,176	48,916,440	36.4
Total value of products	*140,614,481	91,348,889	53.9

* Exclusive of $17,335,033, reported as by-products of other industries, the aggregate value of electrical machinery and apparatus production for 1905 being $157,949,514.

The principal products are summarized as follows:—

Dynamos	$11,084 234	$10,472,576	5.8
Motors	22,370,626	19,505,504	14.7
Carbons	2 710,935	1,731,248	56.6
Incandescent lamps	8,319,159	4,036,112	106.1
Telephone and telegraph apparatus	16,974,892	12,154,678	39.7
Insulated wires and cables	34,519,699	21,292,001	62.1
All other products	59,171,047	33,490,464	76.7
Custom work and repairing	2,798,922	2,063,736	35.6
	$157,949,514	$104,746,319	50.8

The Flaming Carbon Arc Lamp

By L. B. MARKS

A Paper Read at the Atlantic City Convention of the National Electric Light Association

Up to the year 1894 the only arc lamps used in the United States were those of the open arc type. In that year the commercial introduction of the enclosed arc lamp began, and during the past ten years the gradual displacement of the open arc lamps by the enclosed arc has taken place. The manufacture of the open arc type of lamp as used in the United States was practically discontinued several years ago, and since that time the arc lamps made in this country have been almost exclusively of the enclosed arc type.

The mean spherical candle-power of the open arc, operated at its best, is almost double that of the enclosed arc taking the same power. In spite of this difference in the total light flux of the lamps, the enclosed arc displaced the old open street arc mainly because of the following advantages of the former:—

Decreased cost of carbons and maintenance.

Greater steadiness.

Better distribution of illumination.

The lighting interests now have offered for their consideration another lamp of the open arc type, popularly known as the flaming carbon arc lamp.

Let us examine briefly some of the characteristic differences between the flaming carbon arc, the ordinary open and the enclosed arc. In the open arc, as commonly used, the carbons are solid and comparatively free from impurity. The arc is about one-eighth of an inch long, and the light emanates almost entirely from incandescent points, less than 10 per cent. coming from the arc itself.

In the enclosed arc, the carbons must be as pure as possible. The arc, as ordinarily operated, is about three-eighths of an inch long, and, as in the case of the open arc, most of the light issues from the incandescent carbon tips.

In the flaming arc lamp, on the other hand, the carbons are cored and mineralized, that is to say, provided with certain mineral substances either in the core or body of the carbon, or both, which, when feeding into the arc, greatly increase the light-giving efficiency of the latter. The volatilization of the mineralized carbon produces fumes and a considerable quantity of ash, deposits of which are made largely in the portion of the lamp immediately above the arc. In the flaming arc lamp, unlike the open and the enclosed arcs, the bulk of the light emanates from the arc itself, only a comparatively small portion coming from the carbon points. In the lamp with the carbons co-axially arranged, as in Fig. 1, the length of the arc is about five times that of the ordinary open arc, taking the same current and voltage, or about five-eighths of an inch. When both carbons are arranged to feed from above, the arc tends to creep up the sides of the carbons unless special provision is made for holding it in place, so that in all flaming arc lamps with inclined carbons a magnetic field is provided in the lamp by which the arc is continuously blown downward, resulting in a long flame measuring 1 inch to 1½ inches in length.

Owing to the rapidity with which the carbons are consumed in the flaming arc lamps, it has been found necessary to shield the tips as far as possible from "washing" of the air currents in the globe. For this purpose an "economizer" or chamber of highly refractory material is used, which surrounds the ends of the carbons (in lamps in which the carbons are arranged side by side) or encircles the upper carbon (in lamps in which the carbons are arranged one above the other).

The vapour which results from the burning of the mineralized carbons condenses for the most part on the economizer and contiguous portions of the lamp casing. Sometimes a special form of condenser is provided to receive the vapour deposits. As the colour of the condensed vapour is whitish, the deposits above the arc assist in reflecting the light downward. The arc is extremely sensitive to currents of air in the globe and to variations in the magnetic field and regulating mechanism of the lamp.

The regulating mechanism is housed as completely as possible to prevent access of the fine ash and the fumes from the arc. It is not deemed necessary to give the details of the regulating mechanism of the various lamps of the flaming arc type, as in principle the mechanisms are the same as some of those of the older types of arc lamps, with which we are familiar. It should be stated, however, that in most of the types of these lamps used abroad the mechanism is of the wheel and pinion type and far more complicated than that to which we are accustomed in lamps now used in the United States. In some of the more recent types of the flaming arc lamp the mechanism has been considerably simplified.

In Europe there are no less than ten different makes of flaming arc lamps on the market. Among these may be mentioned the Siemens, Koerting & Mathiesen (Excello), and Beck, which are now on the market in the United States. All three of these are of the inclined carbon design, both carbons feeding downward.

Bremer, who was the first to bring out a lamp of the flaming arc type, in 1898, found that when the carbons were impregnated or built up with substances suitable for augmenting the light-giving efficiency of the arc, such as salts of calcium, magnesium, and the like, the scoria produced by the burning of the carbons, when the latter were placed one above the other, resulted in unsteadiness of the arc and liability to extinction. To overcome this difficulty he arranged the carbons side by side, both feeding downward, so that when the arc was formed between the tips of the carbon the molten scoria resulting from the volatilization of the foreign matter in the carbon would drop off without materially interfering with the action of the arc.

The Blondel lamp, in which the carbons are arranged one above the other, has met with considerable success abroad. In this lamp a specially constructed mineralized carbon is used, designed to overcome the difficulties resulting from the production of scoria which Bremer found in operating arcs with the carbons co-axially arranged. In the Blondel lamp the lower carbon (which con-

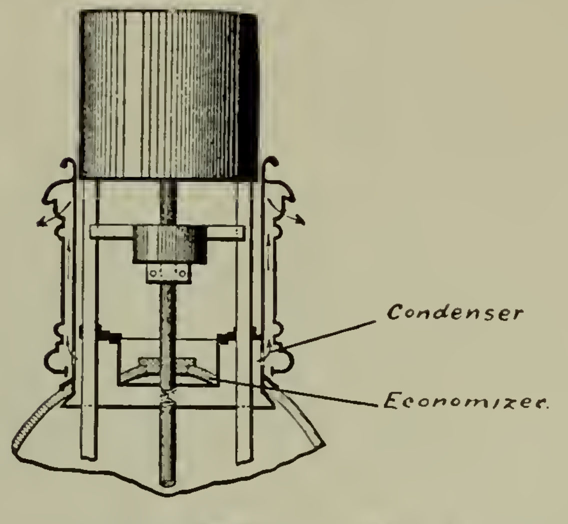


FIG. 1.—A FLAMING ARC LAMP WITH THE CARBONS ARRANGED CO-AXIALLY AS IN THE BLONDEL LAMP

tains practically all of the light-enriching salts) is somewhat larger in diameter than the upper. As the upper carbon in this case produces practically no scoria, the instability of the arc from this cause is minimized. In this type of lamp the magnetic field, which is required with the inclined carbon lamps, is, of course, unnecessary.

LUMINOUS EFFICIENCY OF THE FLAMING CARBON ARC

The following measurements are taken from a report of test made by the Electrical Testing Laboratories, New York, October 6, 1905, on a Koerting & Mathiesen flaming arc lamp, and on a standard 5-ampere, single-globe enclosed arc lamp. The enclosing globe in each case was slightly opalescent.

	Flaming Arc Lamp	Enclosed Arc Lamp
Positive carbon (diameter)	9 mm. (11/32 in.)	13 mm. (1/2 in.)
Negative carbon (diameter)	8 mm.	13 mm.
Mean amperes	8.0	5.1
Mean volts at arc	45.0	81.0
Mean watts at arc	360	413
Mean spherical candle-power	1020	232
Watts per mean spherical candle-power	0.353	1.78

From these measurements it will be seen that the flaming arc lamp gives a little over five times the total luminous flux of the enclosed arc lamp using the same amount of power at the arc.

In the test of the flaming arc lamp just quoted, the carbons used contained calcium salts, giving a yellowish golden tint to the light. Carbons containing these salts produce the highest luminous efficiency in flaming arcs. It should be noted that when carbons (containing barium salts) producing a white light are employed, the luminous efficiency is materially decreased, the reduction amounting to from 25 to 40 per cent., depending upon the character of the mineralization. When carbons (containing strontium salts) producing a reddish-pink light are employed, the luminous efficiency lies about midway between that of the yellow and the white light.

COLOR OF LIGHT

For purposes of street illumination the highly efficient yellow light of the calcium carbon is, in general, suitable; but for interior illumination where colour values are important, the yellow light flaming carbon lamp is objectionable. Under the light of this lamp white material appears cream-coloured, the shades of yellow are intensified, and the colour values at the violet end of the spectrum are naturally distorted. It is quite impossible to distinguish different

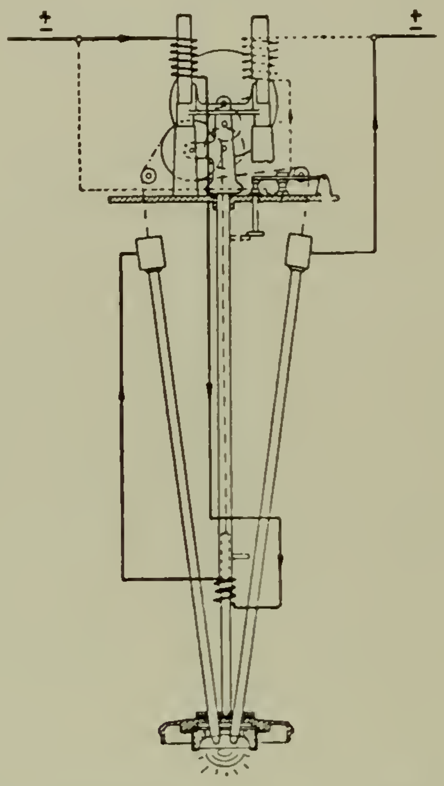


FIG. 2.—DIAGRAM OF ELECTRICAL CONNECTIONS OF THE EXCELLO FLAMING ARC LAMP

shades of dark blue from one another, all of them appearing black. With the white light flaming carbons, however, most of the colours have nearly their daylight value.

STEADINESS OF LIGHT

In the very nature of things the tendency of a long arc operated in the manner employed in flaming arc lamps is toward unsteadiness. The variability of air currents in the globe, the lack of uniformity in the chemical constituency of the mineralized carbon, and the action of the magnetic field (where such is employed), these and other difficulties conspire to produce unsteadiness in the light.

DISTRIBUTION OF ILLUMINATION

The distribution of illumination of the type of flaming arc lamps now in use is quite different from that of the enclosed arc lamp. Most of the light of the flaming arc lamp is thrown downward in a zone from 30 to 90 degrees below the horizontal, the amount of illumination dropping off quickly toward the horizontal W. D'A. Ryan reported recently on a series of tests of flaming carbon arc lamps showing that only about 15 per cent. of the total luminous flux lies between the horizontal and 20 degrees below.*

The maximum illumination of the flaming arc lamp is at about 45 degrees below the horizontal, in which respect the distribution of its light resembles that of the old open arc. The flaming arc, however, sends its rays with almost equal brilliancy through all the angles from 30 to 75 degrees below the horizontal, while the old open arc quickly drops from its maximum on either side of the

FIG. 3.—THE "SNOWBALL" FLAMING ARC LAMP MADE BY THE EXCELLO ARC LAMP COMPANY, NEW YORK. THIS LAMP GIVES A SILVER WHITE LIGHT

45-degree line of vision, and yields a comparatively small proportion of its total flux between zero and 15 degrees below the horizontal. In the

* See Transactions, Illuminating Engineering Society, March, 1906.

enclosed arc lamp, on the other hand, the horizontal illumination is relatively very large, and at 15 degrees below the horizontal the illumination is not far from the maximum.

In the following table are given enclosed and open arc candle-power measurements taken from the report of the committee for investigating the photometric value of arc lamps,

FIG. 4.—A FLAMING ARC LAMP MADE BY THE BECK FLAMING LAMP COMPANY, NEW YORK. IT GIVES A GOLDEN-YELLOW LIGHT, BUT A WHITE OR DEEP RED LIGHT MAY BE OBTAINED BY CHANGING THE CARBONS

and published in the National Electric Light Association Proceedings, 1902. The data are given for the angles immediately below the horizontal,—the important ones in street lighting.

DISTRIBUTION OF ILLUMINATION OF ENCLOSED ARC, OPEN ARC AND FLAMING CARBON ARC LAMPS

	0° (Horizontal) Candle-Power	15° (Below Horizontal) Candle-Power	30° (Below Horizontal) Candle-Power
Alternating-current enclosed arc 7.5-ampere (450 watts)	312	375	445
Direct-current enclosed arc, 6.5-ampere (450 watts)	328	465	579
Direct-current open arc, 9.5-ampere (450 watts)	195	598	1177
Direct-current flaming carbon arc, 8-ampere (360 watts)	917	1312	1754

In this table and accompanying chart the wattage stated refers to the power consumption at the arc. The voltage of the alternating-current arc was 70.7, the power factor being 0.85. The enclosed arc lamps were of the single globe type, the alternating-current arc being provided with a metallic shade. The globes were of opalescent glass, except for the open arc, which was bare. The candle-power measurements of the flaming arc lamps are taken from the test previously quoted in this paper; the globe of

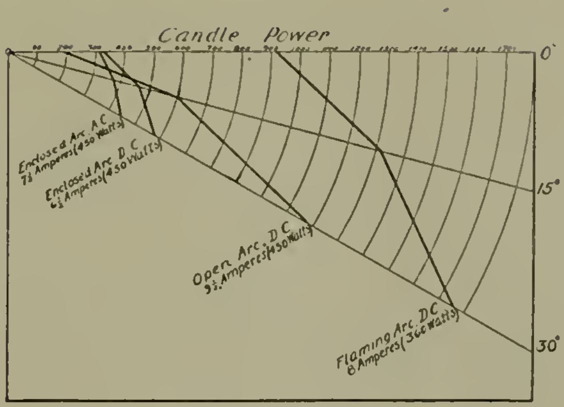


FIG. 5.—DIAGRAM SHOWING LIGHT DISTRIBUTION OF ENCLOSED, OPEN, AND FLAMING ARC LAMPS

this lamp was of slightly opalescent glass.

Taking the 6.5-ampere direct-current enclosed arc, it will be noted that from the horizontal down to about 12 degrees below, the enclosed arc gives more illumination than the 9.5-ampere open arc using the same power. This means that if the lamps were mounted on poles 25 feet above the ground they would give equal illumination at a distance of about 115 feet from the pole; beyond this distance the advantage would be in favour of the enclosed arc. Now taking the case of the flaming arc lamp consuming 360 watts, or four-fifths of the energy of the enclosed arc, the illumination at a distance of 115 feet from the pole will figure out 2.83 times that of the enclosed arc.

From the distribution of illumination, as shown in the chart, it will be seen that this same proportion holds approximately for all distances from the pole greater than 45 feet, at which point the light strikes the ground at an angle of 30 degrees below the horizontal. At distances less than 45 feet from the pole the proportion rapidly changes in favour of the flaming arc and reaches approximately 10 to 1 at a distance of 7 feet from the pole.

With the 7.5-ampere, alternating-current enclosed arc, the amount of illumination distributed through the most effective zone for street illumination is considerably less than that of the direct-current enclosed arc with the same power consumption. The ratio of 2.83 to 1 cited above would for the flaming arc and the alternating-current enclosed arc be 3.3 to 1 at 12 degrees below the horizontal, representing a distance of 115 feet from the pole; 3.5 to 1 at 15 degrees below, representing a distance of 95 feet from the pole; and 3.9 to 1 at 30 degrees below, representing a distance of 45 feet from the pole.

As in the last case, the proportion increases rapidly in favour of the flaming arc as we approach close to the pole. Hence if we are to obtain the most effective use of the remarkably high luminous efficiency of the flaming arc lamp we must provide the lamp with a reflecting device that will materially modify the distribution of illumination of the arc. There is reason to believe that considerable improvement in this respect may be brought about, but the problem is not a simple one. With the present distribution of illumination, the flaming arc lamp, if mounted on a pole having the same height as the poles now in use for street lighting, would produce an illumination in the immediate neighbourhood of the pole entirely out of proportion to that given at a distance of 125 to 250

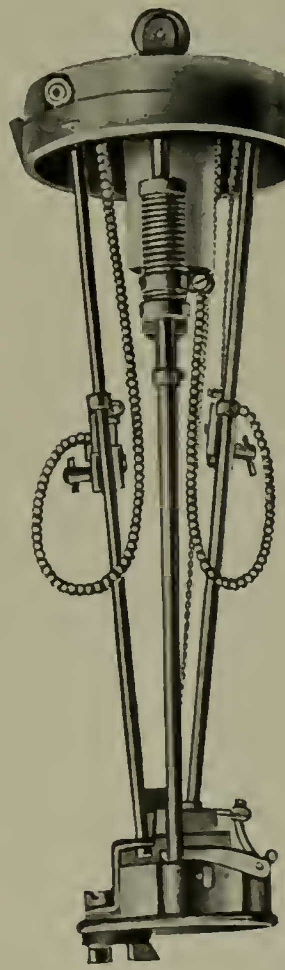


FIG. 6.—INSIDE VIEW OF THE BECK LAMP FOR DIRECT CURENT

feet, which is about one-half the distance that now obtains between poles in arc lighting practice in this country.

To meet this difficulty it is apparent that unless the size of the unit can be materially decreased, the flaming arc lamp must be placed very high above the ground, so high, in fact, that in most cases serious questions arise as to the practicability of such a procedure.

SIZE OF UNITS

The units now commonly employed are 8, 10 and 12 amperes with 45 to 50 volts at the arc. Owing to the special composition of the carbons and the peculiar nature of the arc,

FIG. 7.—THE SIEMENS FLAMING ARC LAMP, SOLD IN THE UNITED STATES BY FELIX HAMBURGER, NEW YORK

obstacles are encountered which make the practical operation of the lamp difficult when smaller currents are used. Professor Blondel writes to the author under date of March 28, 1906, that the smallest practical currents for operating his lamp (before referred to) are "from four to five amperes for direct current and from seven to eight amperes for alternating current." With small currents the luminous efficiency of the arc is very considerably reduced.

COST OF OPERATION. CASE I.—STREET-LIGHTING CIRCUIT

In order to compare the cost of operation of the flaming arc lamp with that of the enclosed arc lamp now commonly used for street illumination in the United States, the writer has taken the case of a lighting circuit in which the lamps are run all night every night in the year, on what is commonly known as the 4000-hour schedule. The present practice in street lighting is to place the poles on which the arc lamps are mounted about 250 feet or more apart.

Assuming that the flaming arc lamp gives five times the illumination of the enclosed arc for the same power consumption (which assumption strongly favours the flaming arc lamp so far as the illumination within the useful zone for street lighting is concerned, as has already been shown in this paper), it is obvious from the law of inverse squares that, for equal illumination midway between the poles, even if the flaming arc were mounted high enough up to give it the advantage of a more favourable distribution of light, it could not replace more than two enclosed arc lamps, each consuming the same amount of power as the flaming arc. Taking a circuit of lamps where two enclosed arcs are thus replaced by one flaming arc lamp, the difference in the cost of carbons and maintenance is as follows:—

STREET ARCS (500 WATTS) OPERATED 4000 HOURS A YEAR

COST OF CARBONS AND MAINTENANCE

	Two Enclosed Arcs	One Flaming Arc (Carbons 10 Cents per Trim)
Carbons	$2.68	$36.50
Trimming	2.34	8.21
Repairs	1.50	0.75
Inspection	0.90	0.90
Inner globes	0.60	....
Outer globes	0.30	0.15
	$8.32	$46.51

The cost of a pair of flaming carbons suitable for an all-night run is taken at 10 cents. It should be noted, however, that the lowest price now quoted in this country for carbons for such service is 15 cents a pair in quantities. In the table which follows, the difference in cost of operation, should the price of carbons fall as low as 2 cents per trim (an extreme case), is given. The cost of the enclosed arc carbons is taken at 2.75 cents per trim, based on an average life of 77 hours per trim. This cost, it will be noted, is higher than that which obtains in most of the larger stations in the country. The enclosed arcs are assumed to be trimmed once a week, the stub of the upper carbon being used the succeeding week as a lower, which is the usual practice. The flaming arcs are trimmed once a day. The cost of trimming and cleaning the lamps is put at 2.25 cents per lamp, an average figure.

The cost of repairs per lamp is assumed to be the same in both cases, although with the present types of flaming arc lamps the cost of repairs would undoubtedly be very much higher than that of the enclosed arc. As bearing out this conclusion, it may be stated that the cost of repairs of the old open-arc lamp now in use in this country is considerably higher than that of the enclosed arc. S. G. Rhodes, in a paper read at the convention of the Asso-

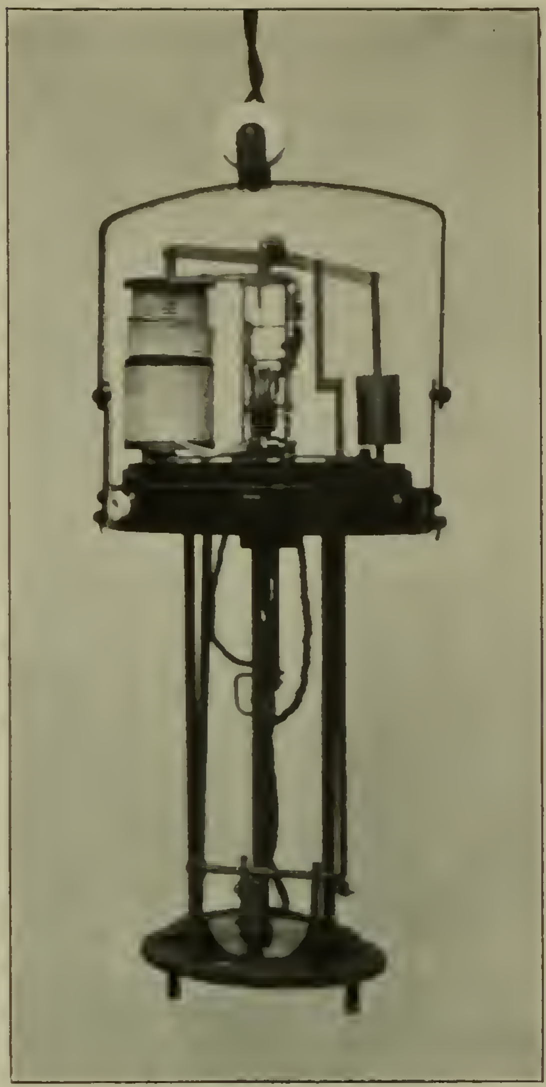


FIG. 8.—VIEW SHOWING THE MECHANISM OF THE SIEMENS FLAMING ARC LAMP

ciation in 1904 (National Electric Light Association Proceedings, 1904, page 129), stated that on the circuits of the New York Edison Company operating enclosed arc lamps of the multiple direct-current and series alternating-current types, and series open arc lamps, the cost of repairs of 600 open arc lamps was as large as that of 2000 enclosed arcs.

The cost of inner globes for the enclosed arc lamps is figured at 15 cents each, two globes per lamp per year being allowed. As an offset against the cost of inner globes for enclosed arc lamps the cost of the "economizer" for the flaming arc lamp should undoubtedly be taken into consideration, but no allowance has been made for this destructible element in the flaming arc lamp. The cost of outer globes is figured at 45 cents each, the average life of a globe being taken as three years. In the flaming arc lamp the life of the globe would probably be considerably less than this.

The station cost of producing energy is taken at values from 0.75 cent to 2.75 cents per kilowatt-hour. This cost includes the cost of coal and water and that proportion of the station labour and maintenance account chargeable to the arc lighting system.

It will be noted from the table and

chart that when the station cost of producing energy is less than two cents per kilowatt-hour, and the price of flaming arc carbons 10 cents per trim (which is one-third less than the present price in this country), it would not pay in this case to install the flaming arc even if the extra cost of new lamps and of installing them be left out of consideration, and even though one flaming arc replace two enclosed arcs. When the cost of energy is high, however, the flaming arc lamp makes a more favourable showing than indicated above, particularly if the cost of carbons is reduced. For instance, at station cost of 2.75 cents per kilowatt-hour for energy, the cost of operation of the two 500-watt enclosed arc lamps is $118.50 per year, as against $101.51 per year for one 500-watt flaming arc with carbons at 10 cents a pair, and as against $83.26 with carbons at 5 cents a pair.

On the other hand, if the station cost of energy is very low, say 0.75 cent per kilowatt-hour, the cost of two enclosed arc lamps is $38.50 per year, as against $61.51 per year for one flaming arc with carbons at 10 cents a pair, $43.26 a year with carbons at 5 cents a pair, and $33.31 with carbons at 2 cents a pair. The cost of operation per year of two enclosed arcs and of one flaming arc for costs of energy and of carbons other than above stated may be readily obtained from the tables.

CASE I

STREET-LIGHTING CIRCUIT

Station Cost of Producing Energy per Kilowatt-Hour	Cost of Energy, Carbons, Trimming, Inspection, Repairs, Globes, 4000 Hours									
	Two Enclosed Arc Lamps (500 Watts Each)	One Flaming Arc Lamp (500 Watts)								
		Cost of Carbon per Trim								
	2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	$118.50	$101.51	$97.86	$94.21	$90.56	$86.91	$83.26	$79.61	$75.96	$72.13
2½c.	108.50	96.51	92.86	89.21	85.56	81.91	78.26	74.61	70.96	67.31
2¼c.	98.50	91.51	87.86	84.21	80.56	76.91	73.26	69.61	65.96	62.31
2c.	88.50	86.51	82.86	79.21	75.56	71.91	68.26	64.61	60.96	57.31
1¾c.	78.50	81.51	77.86	74.21	70.56	66.91	63.26	69.61	55.96	52.31
1½c.	68.50	76.51	72.86	69.21	65.56	61.91	58.26	54.61	50.96	47.31
1¼c.	58.50	71.51	67.86	64.21	60.56	56.91	53.26	49.61	45.96	42.31
1c.	48.50	66.51	62.86	59.21	55.56	51.91	48.26	44.61	40.96	37.31
¾c.	38.50	61.51	57.86	54.21	50.56	46.91	43.26	39.61	35.96	32.31

CASE II.—STREET-LIGHTING CIRCUIT

It has already been stated that the flaming arc lamp is not at present commercially operative in small units. Let us take a hypothetical case and assume that it is feasible to operate a unit taking one-fifth of the power of the present enclosed arc lamp and giving the same amount of illumination as the latter. If now we replace each enclosed arc lamp of the circuit by such a flaming arc lamp consuming one-fifth of the power, we find the following costs of operation in the two cases, it being assumed that the cost of repairs, globes, cleaning and inspection will check up evenly against each other in both instances.

From the table it is evident that, even waiving the cost of new lamps and expense of their installation, it would not pay in order to secure the same illumination in a street-lighting system in which the station cost of producing energy is 1 cent per kilowatt-hour (a practical case) to substitute flaming arc lamps taking only 100 watts for enclosed arc lamps taking 500 watts each, unless the price of carbons for the flaming arc falls below 3 cents a pair.

CASE II

STREET-LIGHTING CIRCUIT

Station Cost of Producing Energy per Kilowatt-Hour	Cost of Energy, 4000 Hours		Cost of Energy Carbons, Trimming, 4000 Hours									
	One Enclosed Arc Lamp (500 Watts)	One Flaming Arc Lamp (100 Watts)	One Enclosed Arc Lamp (500 Watts)	One Flaming Arc Lamp (100 Watts)								
				Cost of Carbons per Trim								
			2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	$55	$11	$57.60	$55.71	$52.06	$48.41	$44.76	$41.11	$37.46	$33.81	$30.16	$26.11
2½c.	50	10	52.60	54.71	51.06	47.41	43.76	40.11	36.46	32.81	29.16	25.11
2¼c.	45	9	47.60	53.71	50.06	46.41	42.76	39.11	35.46	31.81	28.16	24.11
2c.	40	8	42.60	52.71	49.06	45.41	41.76	38.11	34.46	30.81	27.16	23.11
1¾c.	35	7	37.60	51.71	48.06	44.41	40.76	37.11	33.46	29.81	26.16	22.11
1½c.	30	6	32.60	50.71	47.06	43.41	39.76	36.11	32.46	28.81	25.16	21.11
1¼c.	25	5	27.60	49.71	46.06	42.41	38.76	35.11	31.46	27.81	24.16	20.11
1c.	20	4	22.60	48.71	45.06	41.41	37.76	34.11	30.46	26.81	23.16	19.11
¾c.	15	3	17.60	47.71	44.06	40.41	36.76	33.11	29.46	25.81	22.16	18.11

At 5 cents a pair, which is one-third of the price now quoted in the United States (for the long-burning carbons) and somewhat lower than the lowest price quoted by the principal makers in Europe, the cost of operation per lamp per year in this supposed case would be $22.60 for the enclosed arc as against $30.46 for the flaming arc. The cost of operation per lamp per year for various costs of energy and of carbons is shown in the table and accompanying chart.

CASE III.—COMMERCIAL OUTDOOR CRCUIT

In this case the cost of operating a commercial outdoor circuit, with lamps burning on an average approximately three hours a day, or 1000 hours a year, equipped with the present type of flaming arc lamps, will be compared with the cost of operating a similar circuit equipped with enclosed arcs.

The cost of enclosed arc carbons per trim, cost of one trimming per lamp and the cost of repairs, inspection and globes per lamp per year are taken at the same figures as in the preceding case. The enclosed arcs are trimmed ten times for this service and the flaming arcs eighty-three times. The safe allowance under commercial conditions is taken as 100 hours per trim for the enclosed arc and 12 hours per trim for the flaming arc. Following are the data of cost of carbons and maintenance per lamp per year, figuring the cost of flaming arc carbons at 15 cents per trim (present cost):—

COMMERCIAL OUTDOOR ARCS (500 WATTS) OPERATED 1000 HOURS A YEAR

COST OF CARBONS AND MAINTENANCE

	Enclosed Arc	Flaming Arc (Carbons 15 Cents per Trim)
Carbons	$0.275	$12.45
Trimming	0.225	1.87
Repairs	0.75	0.75
Inspection	0.90	0.90
Inner globes	0.15	....
Outer globes	0.15	0.15
	$2.45	$16.12

The total cost of operation, including cost of energy (500 watts), cost of carbons, trimming, repairs, inspection and globes for both types of lamps, is given in the accompanying table of Case III.

Taking the cost of flaming arc carbons at 15 cents per trim (present cost) and the cost of energy at station-cost of 1 cent per kilowatt-hour, the cost of carbons and maintenance of the flaming arc lamp per year of 1000 hours under the assumption above made would be, as shown in the table, $21.13, as against $7.45 for the enclosed arc. Hence, even waiving the additional cost of new lamp and installation, it would not pay, from the standpoint of illumination, to substitute the flaming arc for existing enclosed arcs under the above conditions unless the flaming arc lamps replace at least three enclosed arcs.

Neither would it pay in the above case with carbons at 10 cents per trim, the relative cost of operating the lamps here being $16.97 and $7.45. But with flaming carbons at 5 cents a trim, the relative costs of operation being $12.82 and $7.45, the substitution would pay if the flaming arc replaces at least two enclosed arcs. If the cost of flaming arc carbons were reduced to the present cost of enclosed arc carbons (2.75 cents per trim), the relative costs of operation would be $10.95 and $7.45, and in this case still it would not pay to make the substitution unless at least two enclosed arcs are replaced by one flaming arc. From the table

CASE III

Commercial Outdoor Circuit

Station Cost of Producing Energy per Kilowatt-Hour	Cost of Energy, Carbons, Trimming, Inspection, Repairs, Globes, 1000 Hours				
	One Enclosed Arc Lamp (500 Watts)	One Flaming Arc Lamp (500 Watts)			
	Cost of Carbons per Trim				
	2¾c.	15c.	10c.	5c.	2¾c.
2¾c.	$16.20	$29.87	$25.72	$21.57	$19.70
2½c.	14.95	28.62	24.47	20.32	18.45
2¼c.	13.70	27.37	23.22	19.07	17.20
2c.	12.45	26.12	21.97	17.82	15.95
1¾c.	11.20	24.87	20.72	16.57	14.70
1½c.	9.95	23.62	19.47	15.32	13.45
1¼c.	8.70	22.37	18.22	14.07	12.20
1c.	7.45	21.12	16.97	12.82	10.95
¾c.	6.20	19.87	15.72	11.57	9.70
½c.	4.95	18.62	14.47	10.32	8.45

the comparative costs of operation for the various costs of energy and of carbons may be read.

In the statements just made, to the effect that it would not pay to make the substitution of the flaming arc for the enclosed arc under the conditions named, it is, of course, understood that the station is selling energy at a uniform price per unit for both the enclosed arc and the flaming arc. If, however, the mean spherical candle-power produced per unit of energy is made the basis of comparison, the substitution of the flaming arc for the enclosed arc would pay in every case cited in the table, even at the present cost of flaming arc carbons.

For instance, with energy at station cost of 1 cent per kilowatt-hour, the cost of current, carbon and maintenance of a flaming carbon arc is, as appears from the chart, nearly three times that of an enclosed arc taking the same power; but as the flaming arc for this power gives five times the mean spherical candle-power of the enclosed arc, the cost per candle-power of the former is only three-fifths that of the latter. But unless a very intense illumination in a small space is desired (as, for example, for advertising purposes), no advantage would be gained by substituting an intense light for one of smaller candle-power and less intrinsic brightness.

frequent roll changing.

CONCLUSIONS

In summation, we may conclude:—

First—That the flaming carbon arc lamp of commerce produces five times the total luminous flux of the enclosed arc lamp for the same expenditure of electrical power in the arc.

Second—The lamp is well adapted for purposes of illumination where a flood of light is desirable in a single unit, as, for instance, for advertising purposes.

Third—The lamp may be used economically in the lighting of some large interiors, and in large open spaces, such as public squares and wide boulevards, if the lamps are placed at a considerable height, say 40 to 50 feet above the ground.

Fourth—The concentration of such a large flux of light in a single unit renders the lamp unsuitable for purposes of ordinary street illumination in the United States.

Fifth—The advantage of economical production of light is offset by reason of the necessity for frequent trimming with expensive carbons.

Sixth—The fumes and ash given out by the lamp, the unsteadiness of the light, and the objection to frequent trimming, render it unsuitable for most cases of interior illumination.

Electric Power in Steel Works

The extraordinary flexibility of the electric system, says "The Engineer," of London, is causing it to be preferred to the older methods of power transmission, such as the hydraulic and compressed air, even when there is no saving of power. Nowhere is the electric motor more appreciated than in an iron and steel works.

During the process of forging it is necessary for the steel to be frequently turned under the hammer, and to facilitate this operation it is supported in an endless chain running over a toothed wheel hung from the hook of the crane. In the electrically operated turning tackle the mechanism which acts directly on the endless chain occupies the position of the hook on an ordinary traveller. A toothed wheel carries the endless chain holding the forging, and is driven by a 6-H. P. motor.

Probably the most difficult and unpleasnt operation when performed by hand is that of charging metal into a steel furnace, or moving large slabs, blooms, or ingots to and from the reheating furnace. Up-to-date steel works have called electric power into use, and electric charging machines are now beginning to be recognized as an absolute necessity. Electric machines are now used for charging a ton of scrap iron at a time in a steel furnace.

For placing ingots in and taking them out of the reheating furnace a somewhat different machine is required, as in this case a special hydraulic or screw gripping arrangement is necessary to hold the ingot. The machine runs on rails on the floor, the lifting and gripping of the ingot being effected by hydraulic power, for which purpose an electrically driven pump and accumulator are provided.

Small electric locomotives are likely in the future to be largely used in iron and steel works. They are extremely useful for dealing with heavy ladles of molten metal, as the workmen may operate them from a distance. In one locomotive supplied with current from two trolley wires, the motor for propelling it is attached to one of the axles, and a second motor serves to actuate the ladle gear by means of a flexible shaft. The propelling motor gives 25 horse-power, and it will propel the locomotive at four miles an hour.

Roller tables in rolling mills have for years been driven by small steam engines, with much complication of reversing levers and steam piping. They are greatly simplified when driven electrically.

Probably the most notable success of the electric motor next to traction work has been its application to the working of overhead travelling cranes. Instead of it being difficult to buy an electrically driven crane, as was the case only a few short years ago, matters have now completely changed, and it is almost as difficult to obtain one driven by running rope or square shaft.

Electrically driven winches are employed to lift the weights used in breaking rails under test.

Screws on rolling mills are also actuated by electric motors, and with them there is much saving of time and labour, especially where many sections are turned out, necessitating

The Technical Publicity Association

"PUBLISHERS' NIGHT" AT THE MAY MEETING

THE evening of May 3, set for the monthly meeting of the Technical Publicity Association, was designated "Publishers' Night," the principal address being given by John A. Hill, president of the Trade Press Association. In speaking of the work of advertising managers, he said:—

"I know that many of your people keep you hustling on catalogues and bulletins and what not, and give you little time for your newspaper work, but I want to tell you that there is where you can do the most good to your concern. Forget how it used to be done. You are the real pioneers in this business; you must make the precedents.

"Learn early in the game not to compare the circulation of the rates of one paper with another. The field, the expense of editorial and the buying capacity of the subscribers are as wide apart as the stars. Fifteen hundred readers in one field may be worth as many thousand in another. This you must study. See where the connection between the users of your goods and the readers of each paper is. See if the readers can or ought to be buyers.

"Words count in copy, the fewer the better, provided they tell the story. A good maximum for advertisement writers is the directions to new reporters on a great newspaper, 'If you have something to say, say it and then quit.' It may pay to tell the whole story about a small article that is liable to be ordered from the advertisement, but a poor policy on large machinery in which the mission of the advertisement is to provoke an inquiry and get the seller and buyer in touch with each other. Description is necessary, but description of details is better than a treatise on the whole machine.

"May you do your work so well that your employer will look upon your department as just as essential as the power house and of his own volition order the bookkeeper to charge the entire cost of your department to investment, and not expense."

Following Mr. Hill, C. W. Price, president of "The Electrical Review," pointed out the benefits of organization, referred to the broader and better view obtained of one's own affairs and duties by consulting with others in the same line of work, and suggested that one of the results to be obtained by the association was the promotion of good feeling between the publishers and the gentlemen of the advertising profession.

Circulation statements and their occasional unreliability were discussed by E. A. Simmons, vice-president of "The Railroad Gazette." He indicated the good results possible to be obtained by the association by securing authentic information regarding what publishers are doing in the matter of circulation. He referred to the one year or more lapsed subscription policy, and said that his publication found it inadvisable to always cut off the subscriber when his payment lapsed, because, as a class, they would eventually pay, and that, as a matter of fact, the percentage of such subscribers was very small.

W. J. Johnston, of "The Mining Magazine" and "The American Reporter," said that we did not realize the possibilities of foreign trade, and that in this country we can manufacture in eight months enough for the demand for a whole year, while the other four months manufacturers should go abroad. He also said that the demand for foreign trade for American goods would be larger if it could be properly handled.

A. E. Clifford, business manager of "The Engineering Record," referred to the fact that there was not enough personal acquaintanceship between the advertising managers and the publishers. He said that other up-to-date publishers stood ready to help the advertisers in every way possible, and that the members of the association could profit materially by getting in closer touch with the publishers.

R. V. Wright, of "The American Engineer and Railroad Journal," referred to the indirect results to be obtained by the advertising manager by keeping in close touch with the editorial side of the publisher's organization.

P. W. Wade, a member of the association, emphasized the remarks by Mr. Hill regarding the cumulative effect of advertising, and that we should not tell all our story in one advertisement, but carry a definite campaign clear through. He pointed out the value of a trade-mark and its continued use in a particular form, always using fac-simile reproduction.

H. N. Davis, treasurer of the association, referred to his early experiences in advertising, and his reminiscences covered anecdotes of his work as an advertising solicitor as well as a publicity manager.

Rodman Gilder, secretary, referred to the discouraging features of spending money on exhibitions in preference to magazine advertising. He also pointed out the difficulty of distinguishing between various kinds of magazines.

F. H. Gale, president, put in a plea for fair treatment of the advertising solicitor, pointing out that he could sometimes help the advertising manager even though no contract was placed. He referred to the matter of circulation statements, and said that advertisers are entitled to know what publishers are doing for them, whether or not contracts are based on actual circulation.

Difficulties with Electric Locomotives in the Simplon Tunnel

THE motors of two of the three-phase electric locomotives, lent by the Valtellina Railway to the Swiss Federal Railways for a preliminary service in the Simplon Tunnel, have broken down, and require complete overhauling. The failure of the motors is not attributed to any defects in their construction, nor is any fault found with the system, but the opinion of the Swiss technical papers is divided as to the real causes of the failure.

It is generally believed, however, that the conditions which rule in the tunnel are not suitable to electric traction-motors as constructed for ordinary service. The locomotives in question occupy two-thirds of the tunnel section, and act therefore more or less as an air-pump piston. The high air pressure generated as they travel forward reacts on the engine.

There are, besides, water springs in constant flow, which yield, according to the latest report issued by the contractors, a total of about 200 gallons per second. Some of the springs yield warm water, and at parts the tunnel walls have a temperature of 70 degrees F. The air inside the tunnel must therefore be exceedingly damp, and the dampness, it is suggested, percolates through the motor insulation.

In the laboratory of the New York City Health Department, 24 electric heaters are used for boiling ether for testing milk. An electrically heated hot-air bath is controlled by an electric thermostat, and a number of electric sterilizers are also used.

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Leading Articles

Index to Volume XXXVI

The Index to Volume XXXVI of The Electrical Age,—January to June, 1906,—is now ready, and will be mailed free on application.

Electric Heating in the Coming Warm Season

THERE is very little doubt that many central station managers look upon the subject of electric heating as unworthy of any sustained consideration so long as there is any prospect of securing a new power or lighting contract; and yet, as the warm season approaches, is it not a particularly favourable time to take up the heating problem again in a better organized manner than ever before? In many cities the fan motor campaign has been so successful in the past three or four years that central station customers are very favourably inclined toward a further extension of the comforts and conveniences which electricity affords in the torrid days of July and August. Of course, a single fan motor in a house is a mere trifle in itself, as far as the revenue derived from it goes, but it is the very best sort of advertising.

The cost of electric heating is the great stumbling block to its universal application; but while it is relatively more expensive than gas or coal in certain large services, it is not burdensome in cost under the proper conditions where the heat is required for only a short time and at a concentrated spot. In the hot season, thousands of families turn to the gas stove as a relief from the almost intolerable conditions which a coal range at full blast produces in a kitchen, but the gas stove is a great sinner in the consumption of oxygen.

People of means gladly pay the cost of cooking by gas to escape the discomfort of the coal range, and in the residence districts this is precisely the class of customers which the central station serves, or can serve if it tries hard enough. Whether the cost of gas or electric cooking will be reasonable or not depends vastly more upon the handling of the equipment than upon the actual cost per thousand feet or per kilowatt-hour.

Other things being equal, gas at $1 per thousand feet requires a rate of about 2¼ cents per kilowatt-hour for the same cost of cooking. With a low residence rate of 9 cents per kilowatt-hour, electric heating will cost four times as much as gas, relatively speaking, but this is not the end of the matter. A man of means can go seven miles to his office in an open trolley car for 5 cents, against anywhere from 20 to 50 cents in his automobile, allowing for all the charges; but the operating cost of the latter is a small matter to the man who can afford it, in proportion to the comfort and enjoyment secured.

There is no reason why the comforts of electric heating should not be worth more than the actual difference in operating cost as compared with gas. The relative difference may be considerable, but the actual bill may be very small, even with the more expensive method.

In the warm season the central station lighting business is at its lowest ebb. The station lighting machinery is, to a considerable degree, standing idle; lines and transformers are carrying exceedingly small loads. Fixed charges and wages are going on, but the cost of producing a considerable additional output is little more than the extra fuel consumption required. There is every inducement to increase the load on the plant.

The rate which can be given for the heating service depends a good deal upon the amount of current the consumer requires for that purpose. A good start can be made by persuading the customer to take a single heating device on trial for thirty days. Individual heating devices consume comparatively little energy, and if the customer is made acquainted with the energy consumption of a heating device in terms of 16-candle-power lamps and impressed with the fact that the cost drops to zero the instant the switch is opened, it will be much easier to persuade him to make a trial of a heater on his lighting circuit. If the entering wedge opens the way toward a good-sized installation, the time will come when it will pay to install a separate meter for the heating equipment, but this is likely to occur in commercial heating long before it is advisable in residential service.

The customer who handles his trial electric heating apparatus wisely will probably find that his bills are not very seriously increased. Suppose a small urn for heating one pint of shaving water in five minutes daily to a temperature of 200 degrees is taken on trial for a month at 10 cents per kilowatt-hour. The cost for the entire month will be only 16 cents. Suppose a 200-watt flat-iron is placed on trial for a month at the 10-cent rate. If it is used five hours per week, the total cost for the month will be but 40 cents, and the convenience of the device will in most cases establish it permanently in the consumer's favour.

It is most important that the central station manager or solicitor should have personal experience in his own home with electric heating apparatus before he attempts to convert his customers to the new methods. The freedom from heat, offensive products of combustion and leaky valves, and the flexibility and possible absence of all cooking devices between periods of use, owing to the portability of electric heaters, can be doubly emphasized from the personal standpoints of experience. Careful records of the actual cost of various kinds of electric heating at the prevailing rates for current will be most welcome data when the customer is approached. It is a good plan to keep a careful record of heating equipment purchased by customers, to facilitate follow-up work leading to the extension of service.

Absorption of Electric Waves in Space

IN a recent number of "The Electrical Review," of London, Mr. Reginald Fessenden details his observations during his trans-Atlantic experiments between the stations of his company (the National Electric Signaling Company) at Western Tower, Brant Rock, Mass. (near Boston), and Machrihanish, Scotland.

Among other interesting points noted by him is the one that up to a distance of over 3000 miles the intensity of signals falls off as the square of the distance. He had previously demonstrated, by quantitative measurements, made by means of his hot-wire barretter, that this was true up to a distance of 250 miles.

It was also found that the intensities of the signals received by either of the stations mentioned are practically identical on the same night, but the intensity varies to a marked degree on different nights. For example, the intensity of signals on the night of January 31 last was one-thousandth less than on the preceding night, January 30. This Mr. Fessenden believes to be due to atmospheric absorption of the energy of the electric waves. This absorption appears to increase as a high power of the distance, at least up to a certain distance, but from certain results noted, the experimenter was led to believe that after a few thousand miles the rate of absorption becomes constant.

It was also observed that the absorption varies aleotropically on different nights. Thus on one night, stations located in the South can be more readily heard than those to the East or West, and vice versa. There are strong indications that the absorbing masses are not continuous, but somewhat resemble transparent clouds, and also that the size of these clouds varies considerably, their diameter varying from 150 feet within five or ten miles above the ground in tropical countries up to diameters of perhaps two miles, and much higher in the air in northern countries.

The difference in the strength of wireless signals during day time and night time has frequently been observed, and was, perhaps, first announced by Marconi. This difference was attributed to ionization, due to sunlight, at the antenna; but Fessenden points out that insulating an antenna or constructing it of such a size that there is no ionization has no effect on the weakening of the signals.

This difference was very marked in tests made by Fessenden's company on the Amazon River, signals that were of normal strength during the night time becoming inaudible within fifteen minutes after sunrise. Between Machrihanish and Boston, however, this difference is not nearly so much.

Some of the conclusions reached by Fessenden are that large masses of absorbing material, probably ionized air, exist in the upper atmosphere. In temperate climates, the electric waves sent out do not reach up to the absorbing masses, and hence are not absorbed appreciably up to distances of 100 miles. But beyond this distance the waves reach up to this distance and are absorbed. For long distances the absorption may be very great, and more than 99.9 per cent. of the energy may be absorbed.

Sunlight causes the absorption clouds to approach much nearer the ground. The height above the earth at which marked absorption begins to take place may be roughly estimated as about 300 miles at night time and 100 miles during day time for the temperate zone, and 100 miles at night time and 30 miles during day time for the tropics.

The amount of power used in making the trans-Atlantic tests herein referred to was approximately 4 H. P. Arrangements are now being made at the Boston and Machrihanish stations to increase the power to 50 H. P. Fessenden also announces that he will use a detector having approximately ten times the sensitivity of the liquid barretter.

By these means he expects to hear messages with only one one-hundred-thousandth of the maximum strength of the signals on "best" nights. It will be interesting to learn the results of the effects of extraneous electric waves upon so sensitive a detector as the one proposed.

With regard to the prospective commercial success of wireless telegraphy, Mr. Fessenden writes in rather a doleful tone. He says the governments of India, New Zealand, Australia, Mexico, Germany, British Guinea and other places have seriously checked the development of wireless working. His own company, he notes, has expended the sum of $422,000 in experimental work, and had received something like $20,000 from the sale of apparatus.

Towards the close of his article he goes over some of the ground covered by him in a letter to THE ELECTRICAL AGE (December, 1904) relative to the reason for not undertaking overland wireless telegraphy. This was, as previously pointed out in these pages, because wireless telegraphy could not attempt to handle the volume of telegraph business between the large cities.

In view of the admissions which Mr. Fessenden makes as to the varibility of the strength of wireless signals from hour to hour and day to day, one is almost tempted to question his ingenuousness when he says, "Transmission by wireless is, as a rule, more reliable than transmission by wire lines, and on no less than three occasions during the past three or four years our company has offered to handle the business of the Western Union and Postal Telegraph lines. The last occasion was in December, 1904, when all telephone and telegraph lines between

New York and Philadelphia were down and our wireless lines were the only ones working."

In the letter to which we have just referred he frankly stated that the capacity of a single wireless station between the points named was totally inadequate to handle the business between those points. It may now be said that although Mr. Fessenden implies that his wireless stations are located in New York and Philadelphia, the stations in point of fact are at inaccessible points in Jersey City and Camden, N. J., respectively.

A messenger would consume one hour in travelling with his batch of messages from New York to the Jersey City wireless station, and one hour from the wireless station in Camden to Philadelphia. In less time than this the telegraph companies, if so disposed, could send the messages by the hourly express trains that ply between New York and Philadelphia. Mr. Fessenden's offer to the telegraph companies was, therefore, little short of fantastic. He is obviously estopped from retorting that the messages might have been sent to the wireless stations by telephone by his prior statements that all telegraph and telephone wires were down at that time.

Reserve Equipment in Isolated Plants

In the design of an isolated plant, one of the early questions to be settled is the capacity of the generating units most desirable for the installation. It is generally agreed among conservative engineers that some provision against a total interruption of service should be made, but opinions differ widely as to the amount of reserve capacity which should be included. Sometimes the machinery installed is designed simply to take care of the maximum load which the plant will be called upon to carry, the idea being to fall back upon central station service in case of a severe breakdown. In other cases, the entire plant is concentrated in a single generating unit, without any provision for continuous service in case of trouble.

The latter plan has often been criticised and branded as poor practice, and yet it is astonishing how often one will meet with installations which have this one radical defect. The owner seems to be willing to take chances that the engine and generator will not fail, year in and year out, and there is often small realization of the cost of a shut-down in curtailed production. Some of the latest plants are built in this way,—which is our excuse for again referring to the matter.

When central station service is available at the proper voltage and current quality, there is little object in installing reserve equipment beyond the overload necessary to handle the peak of the day's business. Anything in excess of this is idle investment, and one of the first principles in power plant economy is the reduction of idle investment to the lowest possible terms. An isolated plant can often get along with a single generating unit where central station connections can be had, and even if the minimum monthly charge of the central station has to be paid for the readiness-to-serve connection, this is almost always a much smaller sum than the fixed charges upon the machinery capacity in excess of the peak output.

When an isolated plant is equipped with two generating units and central station connections, the flexibility is naturally much greater, for if a break-down occur at any time of the day outside the peak load, the chances are that in many instances the load can be carried by the remaining machine until repairs can be made. An overload of 75 or even 100 per cent. can usually be handled without trouble by a well-designed machine for ten or fifteen minutes, and frequently for a longer period.

In cases where central station breakdown service is not to be had, some reserve capacity in excess of the overload capacity should certainly be provided, if the installation is one in which continuous service is important,—and in but few modern installations is it not essential. Local conditions will influence the reserve apportionment, but in most cases it would seem that the machinerv left in order should be capable of supplying at least half, or better, three-quarters of the peak load under all conditions.

In a building served by four electric elevators, for instance, with two equal-sized generators in the engine room, one or two of the elevators could be shut down in case of the failure of one unit, leaving the other unit to carry a reduced total load until temporary repairs, at least, could be made. The point is simply this: reduced service is an inconvenience, but it is immeasurably better than no service whatever, and a reserve equipment which will carry the tenants through the service period without absolute failure is much more likely to insure satisfaction from reasonable consumers at the end of the year than an equipment which is unable to meet emergencies by a partial supplying of light and power. Half a loaf is better than no bread, even in the isolated plant.

Motor Capacity for Group Drive

In the average machine shop running at full capacity, says E. H. McClintock, in "Machinery," generally at least 75 per cent. of the total machines are running at the same time, and if driven in groups a machine taking a heavy cut at maximum power will be generally balanced by a machine taking a light cut at minimum power. For group driving, determine the average horse-power for each tool, add these together, and use a motor with a capacity of from 40 to 70 per cent. of the total thus obtained. This is excellent practice if one can be sure that no more machine tools are to be added to the motor load. The writer's method is to assume that 75 per cent. of the machine tools installed are to be running at one time, and to provide a motor equal to their combined average horse-power. This would mean only a 30 per cent. overload on the motor if the entire group were temporarily running at one time.

Testing Submarine Signals

Beginning June 1, and operating both day and night continuously, submarine signal bells are being sounded from the lightships at Boston, Pollock Rip Shoals, Nantucket Shoals, Fire Island, and Sandy Hook. This is in accordance with a plan of the United States Government for testing this method of signalling.

In a notice sent to masters of vessels provided with submarine sound signalling apparatus, the request is made to note the distance and direction in which the sound is first heard when the vessel is nearing a lightship, the direction and force of the wind, or any condition which might tend to affect the transmission of the signals. Postal cards containing the questions, with room for the answers, are furnished by the lighthouse inspectors at Boston and at Tompkinsville, Staten Island.

The cars on the Frankfort electric system in Germany are provided with a meter which records the time made between stops and also the current consumed.

Electric Wave Indicators and Meters

By WILLIAM MAVER, JR.

ONE of the first tasks to which Heitz applied himself after his discovery of electric waves in free space in 1884, was to find a direct means of measuring the length of the waves.

Taking the velocity of propagation of electric waves along wires or in air at 186,000 miles per second (or equal to the velocity of light), if the wave length were known, it is evident it would be easy to calculate the frequency of the wave vibrations, and vice versa.

According to the electromagnetic theory of light, electric waves should be amenable to the same laws and tests as light waves or undulations.

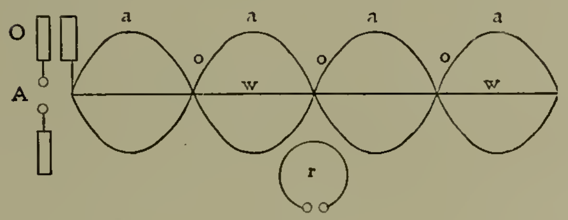


FIG. 1

In his experiments to determine the length of electric waves, Hertz employed the phenomena of stationary waves due to interference. Thus, if a wire end abruptly, electric oscillations set up in the wire are reflected back from the open end of the wire, and if the reflected waves are of the same amplitude as the direct waves, stationary waves are formed with nodes and anti-nodes or loops, the distance between any two nodes being one-half wave length.

Thus, in Fig. 1, a wire W adjacent to an exciting circuit or oscillator O will, if its length be equal to or a multiple of the wave length of the exciting circuit, have waves or oscillations excited in it with nodes o and loops a. By means of a spark resonator r, or secondary circuit, as Hertz termed it, placed at different points along the wire, he was able in a dark room to detect the nodes and loops of the waves; that is, at different points along the wire (at the loops) the spark would be a maximum and at other parts (at the nodes) the spark would be a minimum or absent.

It still remained to measure the wave length in air. For this purpose Heitz employed an oscillator and a large zinc plate, Fig. 2, to reflect the waves, and found that with a given oscillator and resonator the wave-length of the waves along wires and in the air was practically equal. This showed that the velocity of propagation of electric waves was the same in air as along wires, and incidentally afforded the means of measuring the wave length and frequency.

Of course, results were not established immediately, nor without many confirmatory experiments by Hertz and others to explain seemingly contradictory results.

Upon the advent of tuned wireless telegraphy (that is, the employment of transmitting and receiving circuits attuned to corresponding wave lengths), a simple means of determining the wave length or the frequency of the wave in an oscillating circuit became highly essential. Apparatus like the filings coherer and the magnetic and electrolytic detectors are exceedingly sensitive to the presence of electric oscillations, but they do not give any indication or clue to the wave length or frequency.

A number of practical and comparatively simple devices for measuring or indicating the wave frequency or length have been designed by Ferrie, Slaby, Donitz and Fleming.

These wave indicators or meters depend for their operation primarily on the fact that with an exciting oscillation circuit in proximity to a secondary oscillation circuit, a maximum current or potential will be induced in the secondary circuit when the two circuits are in electrical resonance, which will be when they possess equal inductance and capacity, or when the product of inductance and capacity of the respective circuits is equal. The time period T of an oscillation circuit varies with the inductance and capacity of the circuit, according to the formula $T = 2\pi\sqrt{KL}$, where K is capacity and L is inductance.

Knowing these factors, which are measurable in a circuit, the frequency and wave length of the oscillation or wave are readily deducible. For instance, the time T of an oscillation being known, it follows that the frequency n (number per second) of the oscillations or waves, will equal $\frac{1}{T}$.

Knowing the velocity of propagation of the oscillations or waves (186,000 miles per second), it is evident that the wave length will equal velocity V divided by frequency n, or by substitution wave length equals $TV\sqrt{KL} = 2\pi V\sqrt{KL}$.

To illustrate this variation of wave length by variation of frequency of the wave, let us by way of analogy take the following mechanical example. Suppose a car moving on a track at the rate of sixty miles a minute. Let there be a level bed of sand between the rails. Assume a rod to be suspended vertically from the front or rear of the car, its lower end reaching a little below the surface of the sand. If while the train is at full speed the rod is to be moved back and forth across the front of the car, say at the rate of sixty full motions per minute, it will trace sinusoidal curves or waves in the sand. The length of each full wave

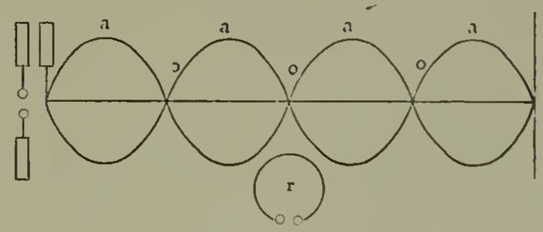


FIG. 2

will be one mile. If the rod be moved back and forth twice as fast it will have 120 full motions per minute and the length of each full wave traced in the sand will be one-half mile, and so on.

If by suitable apparatus the transverse motion of the rod could be varied at will, it is clear that the length of the wave could be varied as desired, the car, of course, maintaining a uniform rate of speed. We have seen that the rate of oscillation of an electric circuit can be varied at will by varying the inductance or capacity of the circuit, consequently the wave length can also be varied by a variation of these factors.

Ferrie's wave meter comprises a horizontal wire connected to the vertical wire between the oscillator and the ground. In the horizontal wire he places a hot wire ammeter, which indicates by its pointer the maximum strength of current in its circuit. Then by varying the length of the horizontal wire, the strength of current will vary from maximum to minimum, the maximum occurring when the horizontal wire is in

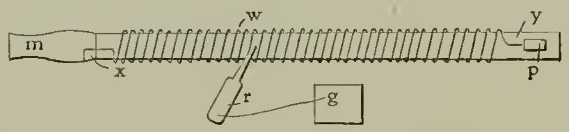


FIG. 3.—SLABY'S WAVE INDICATOR

resonance with the vertical wire. Knowing the capacity and inductance of the horizontal wire in its various lengths, which factors are determinable by laboratory tests, the frequency and wave lengths of the oscillations are readily calculated.

Professor Adolph Slaby has patented the simple wave indicator shown in Fig. 3. It consists of a fine insulated copper wire *w* wound in a close helix on a glass tube of about ¾ inch diameter. One end *x* of the copper wire is connected to a metal sleeve *m* on one end of the glass tube. This serves as a handle by which to hold the glass tube. The other end *y* of the copper helix is attached to a small fluorescent plate *b*, within the tube. This plate consists of a small sheet of paper coated on one side with barium platinocyanide crystals, on the surface of which gold-leaf is rubbed for best results.

In the presence of high-tension electric discharges this plate becomes fluorescent, the phenomenon being due, it is thought, to cathode rays or to ultra-violet rays accompanying the discharges. Other metals than gold can be used for this purpose, but non-oxidizable metals are preferable.

When the tube is held by the handle in the vicinity of an oscillating circuit, the maximum brilliancy of the plate is indicated when the respective circuits are in resonance, the potential at that time being a maximum at *p*.

In order that the device may be employed to measure the wave length or frequency of an oscillating system, the metal rod *r* is used. This is capable of being moved along the coil, and is connected to an earth plate *g* by a wire. In this arrangement, to obtain the highest efficiency, the terminal *x* of the coil is brought back through the tube to the fluorescent plate *b*. With this arrangement, the maximum brilliancy of the plate coincides with the greatest difference of potential between the terminals of the coil. In using this device the earth plate, which is preferably of lead, is merely placed on the ground.

To bring about tuning, the rod *r* is moved back and forth until maximum brilliancy is obtained. On the tube a scale is provided, on which the wave length or frequency at any given point of the coil may be calibrated.

According to Professor Slaby, if the coil be brought very near to the oscillating system under test, the excitiation of the coil is due to electromagnetic radiation. When further removed, the effect is due to electrostatic action, principally through the earth.

Fig. 4 shows a wave-meter devised by Professor J. A. Fleming somewhat on the foregoing described plan. A long coil *w* is of fine copper wire insulated with silk, closely wound spirally on a tube of glass or ebonite, and supported by insulating stands *SS*. A sliding contact *K* connects any desired portion of the spiral to earth by means of the wire *w*'. The left end of the wire *w* is connected to one terminal of a condenser *C*, the other terminal of which is connected to the aerial wire *A*.

The oscillations set up by the usual oscillator are communicated to the spiral wire, and oscillations are established in the latter, and are reflected at the sliding contact *D*, forming stationary electric waves. The contact is moved along the coil back and forth by means of the handle *h* until the length of the coil from *K* to *K*' is equal to one complete potential wave.

To indicate this condition, advantage is taken of the well-known fact that an exhausted tube becomes luminous in the presence of high-potential, high-frequency electric waves. In this case, when the tube shows maximum brilliancy at the points P^1 and P^3 and minimum brilliancy at point P_2, the coil is oscillating in resonance with the aerial wire.

The frequency of the oscillation in so much of the coil as is in operation at this time depends on its inductance and capacity. These factors may be measured, the result being read off directly from the scale *N* by means of the pointer carried on the sliding contact. When the sliding contact is not placed at a point that coincides exactly with a complete wave length or a multiple of the wave length, the tube will glow irregularly in any position.

A more convenient instrument than those described is the Donitz wave-meter, which is extensively employed by the Telefunken Wireless Telegraph Company in practical work, especially in the initial tuning of aerial circuits with the station outfit.

A side view of this wave-meter is shown in Fig. 5 and a top view in Fig. 6. It consists of a coil of fine copper wire *S* connected in series with a condenser *c* and with the primary wire *i* of a small induction coil, by means of the wires 1, 2, 3.

The primary *i* is a single turn of heavy copper wire. In the circuit of the secondary wire i^1 there is a heat wire *w* contained in the top of one of the legs *h* of the *U*-shaped tube, which is partly filled with a coloured liquid, as indicated. When current is induced in the heat wire, the heat developed expands the gas or air in the top of the tube, depressing the liquid in one leg and raising it in the other leg of the tube. This device, originally due to Sir William Snow Harris, is termed the Riess air thermometer.

The condenser *c* is made up of two series of semi-circular thin metal plates, properly separated from one another and contained in a circular case filled with oil. To allow ready adjustment of the capacity, one of the series of plates is fixed, the other series being movable to and from the fixed series by means of a spindle *a* and knob *g*. A pointer *z* is attached to this knob and is movable with the knob over the cover of the case around a graduated scale.

When the coil *s* is placed within the influence of the field of force of an external oscillation circuit, oscil-

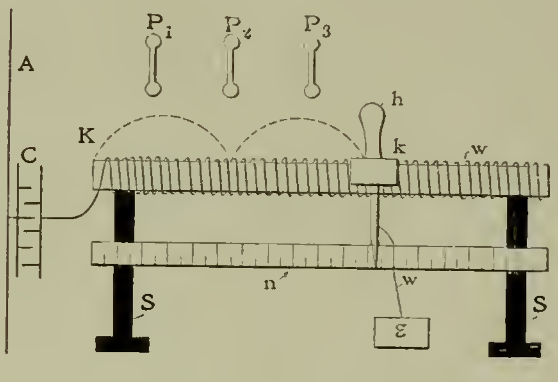


FIG. 4.—FLEMING'S WAVE-METER

lations are inductively set up in the circuit of the wave-meter. The capacity of the circuit is then adjusted by turning the knob *g* until the two circuits are in resonance, which will be indicated when the liquid is at its maximum height in the left leg of the tube, at which time the pointer will be at a given point, opposite which is marked the wave length corresponding to the capacity and inductance of the oscillation circuit at that time. The primary wire *i* is adjustable to or from the secondary wire i^1 for the purpose of regulating the amount of current induced in the secondary wire.

In order to enlarge the scope of the wave-meter, the inductance coil *s* is readily interchangeable with two other coils of different inductances. The inductances of these coils are so calculated that by a suitable selection of coils the inductance of the oscillation circuit may be varied in the proportion of ¼ : 1 : 4, the wave lengths corresponding with the respective coil employed being indicated in meters on the scale *t*, Fig. 4.

By means of these coils the apparatus is given an inductance ranging from L = 140 to 1120, as indicated by the figures on the scale. If desired, it is obvious that the frequency of the oscillations instead of the wave lengths might be indicated on the scale.

In oscillation circuits such as vertical wires, it is found that there is usually two or more (superposed) oscillations of different frequency concurrently in the circuit. By plotting a diagram of the readings of the wave-meter, it is possible to ascertain whether there is more than one system of oscillations in the external oscillation circuit, and if so, what its wave-length is. This is done by noting the respective adjustments of the apparatus at which the current reaches a maximum.

The relative amplitudes of the separate oscillations also are indicated by the magnitude of the current strength, as shown by the height to which the liquid is raised. Furthermore, the sharpness of the tuning may be deduced by observing whether the movement of the liquid in the tube decreases rapidly or slowly as the oscillation circuit undergoes small variations of adjustment towards either side from the position of resonance. In effect, this operation of the wave-meter corresponds to that of a sound resonator in selecting or analyzing the tone to which the resonator is attuned.

In ordinary practice, the wave-meter is placed about one foot or 18 inches from the primary oscillation circuit. The entire outfit occupies about one cubical foot of space. To test the wave length of an aerial circuit, a small coil of wire s^1 in a loop from the aerial is placed concentrically within the wave-meter coil *s*. For more accurate tests and to avoid reactance effects upon the coil s^1, the latter should not approach within one inch of the coil *s*.

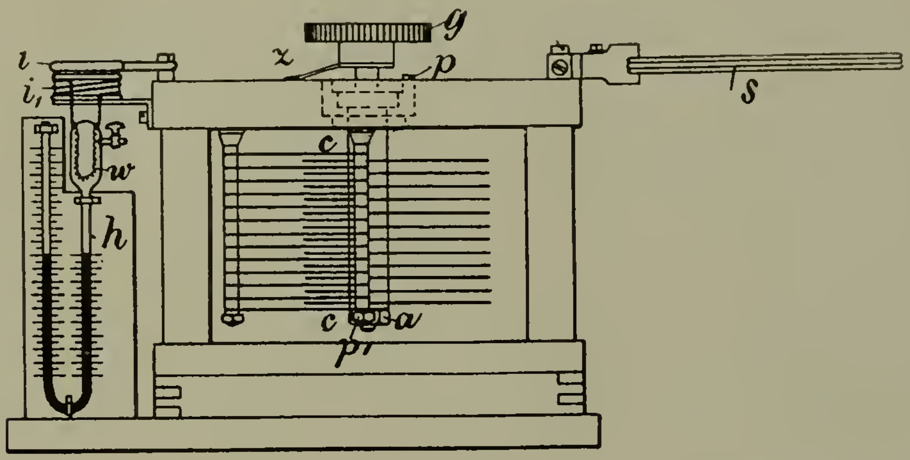
There is an electro-mechanical device used in connection with the Cuttriss siphon recorder employed in cable telegraphy that bears an analogy to the adjustable wave-meter, and, in fact, to the entire method of tuning by varying the inductance or capacity in wireless telegraphy. For that reason it may not be amiss to give here a brief description of this device.

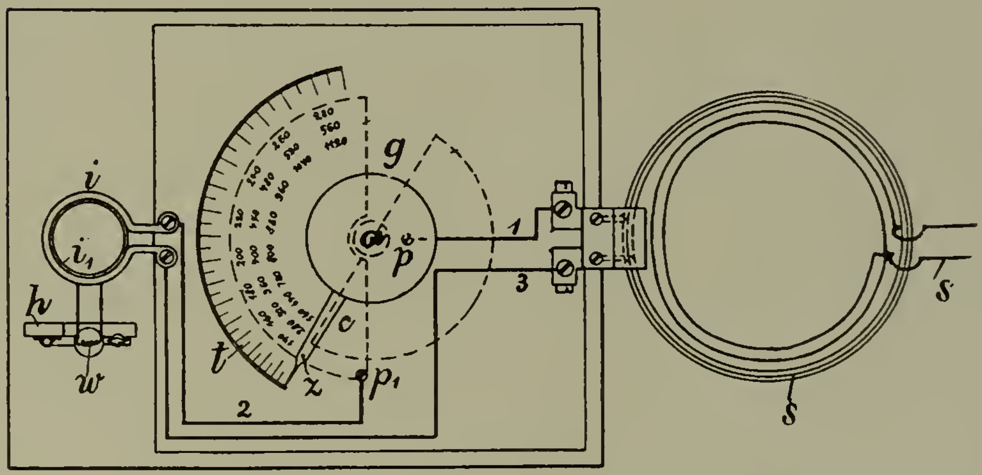
The siphon in Fig. 7* consists of a small glass tube *Si* carrying on its lower end a minute piece of soft iron *T*. This iron is placed close to, but does not touch, the paper strip *P*. The paper at this point passes over a magnetic table *M*, which is magnetized by the cores of an electromagnet *EM*. Magnetic vibrations are set up in the table by means of the vibrating reed *R*, to which is attached a glass tube *G* partly filled with mercury. At its upper end the reed *R* carries the armature of the electromagnet M^1.

When the tube *G* is set in vibration, it continues to vibrate in the well-known way common to circuits connected up in the manner shown in the diagram. But the rate of vibration of the rod *R* may be varied by raising or lowering the column of mercury contained in the tube *G*. This is readily done by means of the flexible rubber tube R^1 connecting the glass tube with a reservoir *X* in which the mercury is stored. By adjusting the amount of mercury in the tube by means of a plunger *P*, a point is reached where the vibrating rate of the tube coincides with the natural rate of vibration of the siphon. When this result is obtained it is indicated by the appearance of a fine line of dots on the moving paper strip and signals are recorded by marks to the right and left of zero.

As electrical inductance and capacity are usually likened in mechanics to inertia and elasticity, respectively, the tuning in this case is accomplished by a variation of what in wireless telegraphy would correspond to inductance. To carry the idea a little further, it may be remarked that the fundamental rate of vibration of the siphon might easily be ascertained by noting the musical tone produced by the rod *R* when vibrating in unison with the siphon.

Professor J. A. Fleming has devised the wave-meter outlined in Fig. 8. This comprises an arrangement whereby the inductance and capacity of the meter are increased or decreased simultaneously and in the same proportion by the movement of a handle H_2 for the purpose of varying the wave length of the circuit. In this meter the condition of maximum current strength in the meter oscillation circuit, and consequently of resonance with the exciting oscillation circuit, is indicated





FIGS. 5 AND 6.—SIDE AND TOP VIEWS OF THE DONITZ WAVE-METER

* Reproduced from the author's work, "American Telegraphy," with consent of the publishers.

by the maximum brilliancy of the glow in a sensitive tube, which, filled with the rare gas neon, is rendered luminous by electric oscillations.

In the figure, *S S* is an inductance consisting of a helix of No. 14 copper wire, wound on an ebonite tube *d*. The turns of the helix are about one-eighth of an inch apart and cover about 3 feet of the tube *d*.

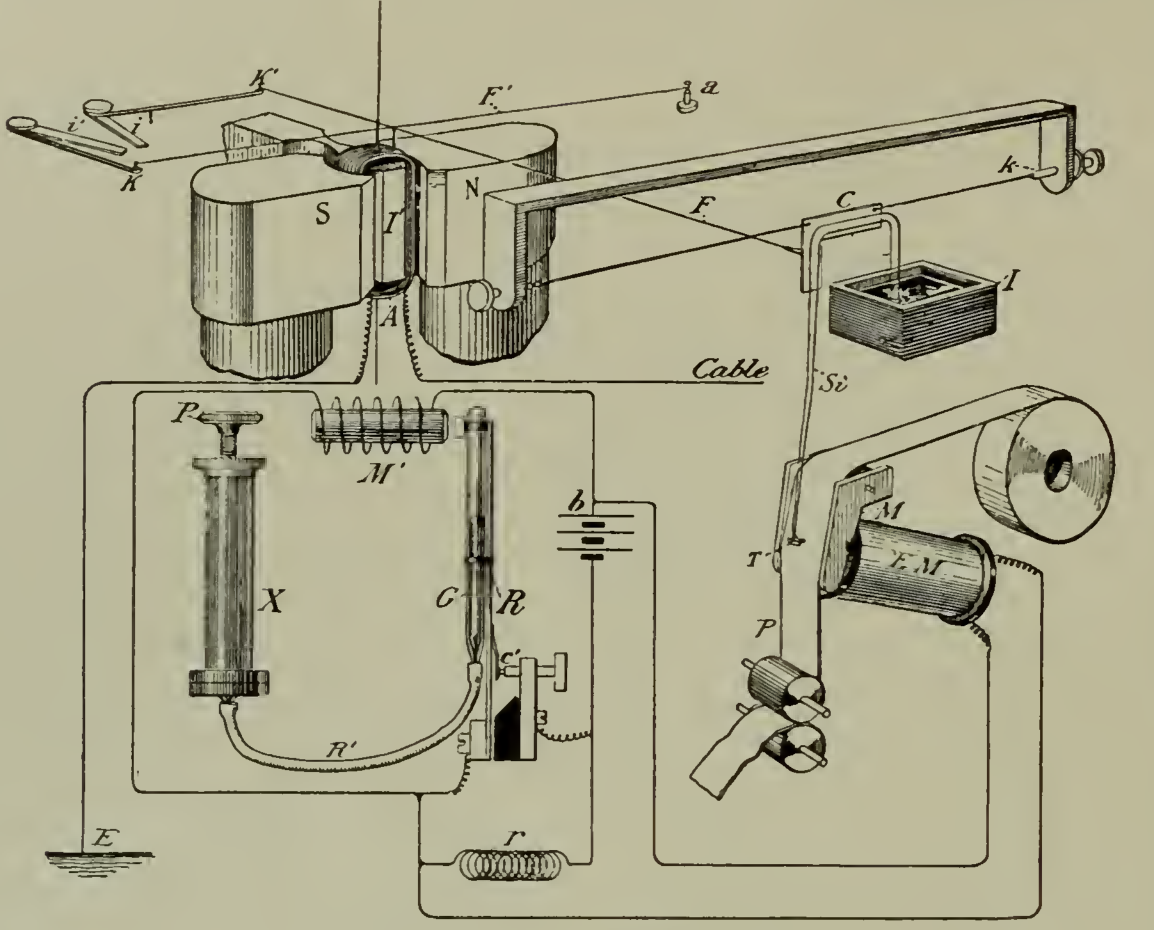


FIG. 7.—THE CUTTRISS SIPHON RECORDER

The capacity is supplied by two metallic tubes *I*, *J*, about 30 inches long, and separated by the ebonite tube *d*, which serves as the dielectric. Ebonite or some other dielectric that does not vary with the frequency must be selected. The inner metal tube *I* is fixed; the outer metal tube *J* is movable laterally.

A metal rod *a* and a sliding contact *K* are attached to the outer ca-

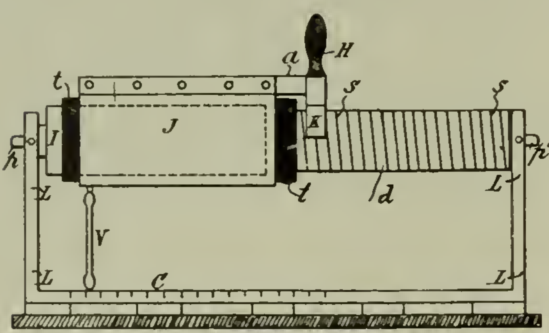


FIG 8.—ANOTHER WAVE-METER DEVISED BY FLEMING

pacity tube *J*. The sliding contact *K* makes electrical contact with the wire or inductance *S*, along which it is movable by means of the insulated handle *H*. The same movement of this handle moves the tube *J* more or less over the inner tube *I*. Thus, when the handle is moved to the right, fewer turns of the spiral wire are in the circuit, and less of the tube *J* covers the tube *I*. Consequently, the inductance and capacity, respectively, are decreased, and the reverse is true when the handle is moved to the left.

The left end of the inductance *S* is open; its right end is connected to a pin p^1 on a bent metal rod *LL*, about one inch wide and one-eighth inch thick. The left end of the inner tube *I* is connected by pin *p* to the rod *L L*. Thus the inductance and capacity are in series.

The neon tube *V* is connected across the terminals of the capacity as indicated. In practice, this tube consists of two bulbs connected by a narrow glass tube of uranium glass and filled with rarefied carbonic-acid gas, or preferably with the gas neon. This tube is carried by and moves with the metal tube *J*, and carries an index pointer, not shown, that indicates the wave length or frequency on the scale *C*.

In the use of this instrument, a part of the aerial wire in operation is laid parallel to the copper rod *L L*, and the handle *H* is moved back and forth until the point is found where the glow in the neon tube is brightest, when the oscillation circuits will be in resonance. At such time the index will indicate on the scale *C* the wave length, frequency or oscillation constant $\sqrt{KL}$ of the particular oscillation under test., for, as previously noted, the oscillation circuit may have two or more quite different oscillations.

In the use of this instrument, resonance is also indicated by means of a thermal couple in the wave-meter circuit, and connected with a galvanometer. In this case, the maximum deflection of the galvanometer occasioned by maximum current in the thermal couple indicates resonance.

Fleming has shown by actual measurement that the wave length in the aerial wire is approximately five times the length of the antenna, instead of four times, as it is generally supposed to be. This apparatus is used by the Marconi Wireless Telegraph Company, and has, it is said, been found of much utility in practical operation.

The New England Section of the Illuminating Engineering Society

THE New England Section of the Illuminating Engineering Society held its fourth regular meeting at the American House, Boston, on May 22. The subject for the evening was "Street Lighting," and the following papers were presented:—"A Method of Street Lighting by Incandescent Lamps," and "Lighting of Streets by the Incandescent Mantle Burner System."

A general discussion followed the reading of the papers, and was taken part in by a large number of those present. J. W. Cowles, of the Boston Edison Company, said that he was especially interested in the subject, as his company was at present operating about 6000 series incandescent lamps for street lighting. He also discussed the relative advantages of 25 to 32-candle-power units for general use. Mr. Sargent, of Haverhill, in reply, advocated a higher candle-power, and thought that 40 candle-power was better adapted for ordinary service.

Considerable comment was made on the G. E. M. series incandescent lamp, and Messrs. Brown, of the Boston Edison Company, and Sargent, of Haverhill, said that they were using a number of them and obtaining good results.

The question of reflectors and the æsthetic side of street lighting were taken up by Mr. Barnes, of Providence, and others, and the need for a more efficient and better appearing street reflector was generally admitted.

The colour of incandescent and Welsbach lamps and its effect on general illumination were also discussed.

A Motor-Driven Dry-Dock Pumping Plant

At the United States Navy Yard in Boston

By H. S. KNOWLTON

FIG. 1.—THE UNITED STATES CRUISER "MARYLAND" ENTERING THE NEW DRY DOCK IN THE BOSTON NAVY YARD. THE BUILDING IN WHICH THE PUMPING PLANT IS HOUSED IS SHOWN AT THE LEFT

ONE of the largest stationary dry docks in the world was opened for service at the Boston Navy Yard on August 12, 1905. The docking facilities of the Boston yard had long been inadequate to meet the requirements of the most modern vessels, and it was early foreseen that, with the continued rate of increase in the size of warships, additional means of docking vessels at the more important yards would become necessary. The construction of the new dock at Boston was therefore undertaken, five years being required for the completion of the work.

To the electrical engineer the most interesting point in connection with the Boston dock is the important part played by electricity in its operation, although the general features of the dock's construction are noteworthy. The progress of acceptance tests by the Government has rendered it advisable to wait until the present time before giving any particulars of the plant. The new dock is known as Dry Dock No. 2 at the Boston yard, and it is 788 feet in maximum length, 114 feet in maximum width and 30 feet deep above the sill at mean high water. The total width of the excavation was about 130 feet, and its greatest depth more than 50 feet, while the work of building it required the excavation of 170,000 cubic yards of blue clay and hard pan. The walls and floor were built of granite and concrete, about 62,000 cubic yards of the latter and 21,000 cubic yards of the former being required. The capacity of the dock is 18,600,000 gallons of water, and the total cost about $500,000. The first vessel to enter the dock was the United States 15,000-ton cruiser "Maryland." Fig. 1 shows the "Maryland" at the entrance of the dock, the circular brick building in which the pumping plant is housed being shown at the left.

The building, a pump well as it is called, is fitted with a steel-supported glass roof, and is tastefully trimmed with granite blocks. The well is 34 feet in diameter and about 56 feet deep below the ground level. It is lined inside with white enamelled tile, and contains 1,000-H. P. in main pumps, 150-H. P. in auxiliary drainage pumps, and a 20-H. P. pressure pump, besides a transformer plant and a controlling switchboard. The pump well is the electrical distribution center for the capstan motors of the new dock and also of the old dock, No. 1. The pumping plant is connected so that either dock can be cleared of water by it at will.

Fig. 2 shows a general view of the pump well interior taken from the top of the stairway by which the attendants pass from the ground level to the machinery floor. Below the machinery floor is a pit 19 feet deep, containing the intake pipes from the two docks and two centrifugal drainage pumps. All the motors are located on the floor of the machinery room, and are of the Westinghouse type "C" induction form, with a three-phase primary winding and short-circuited squirrel-cage rotor.

Three-phase 60-cycle current is supplied from one of the power houses in the yard through an underground cable line about 1800 feet long at a potential of 2000 volts; it passes into the pump wells and to the transformer plant by lead-covered cables carried beneath the stairway. There are three 375-K. W. oil-cooled transformers beneath the switchboard galley shown in Fig. 2, which reduces the tension to 220 volts for the operation of the motors.

The switchboard consists of three panels of blue Vermont marble, two of them being devoted to the main pumps, while the middle panel takes care of the auxiliary pumps. There are two main pumps, each consisting of a 48-inch centrifugal direct-connected to a 500-H. P. motor; two 12-inch centrifugals in the pit for drainage purposes, direct-connected in each case to a 75-H. P. motor; and also the 20-H. P. 5-stage centrifugal previously mentioned, which supplies the hydraulic valves with water.

All the pumps are governed by controllers mounted as shown in Fig. 2, at the edge of the switchboard gallery. One of the 500-H. P.

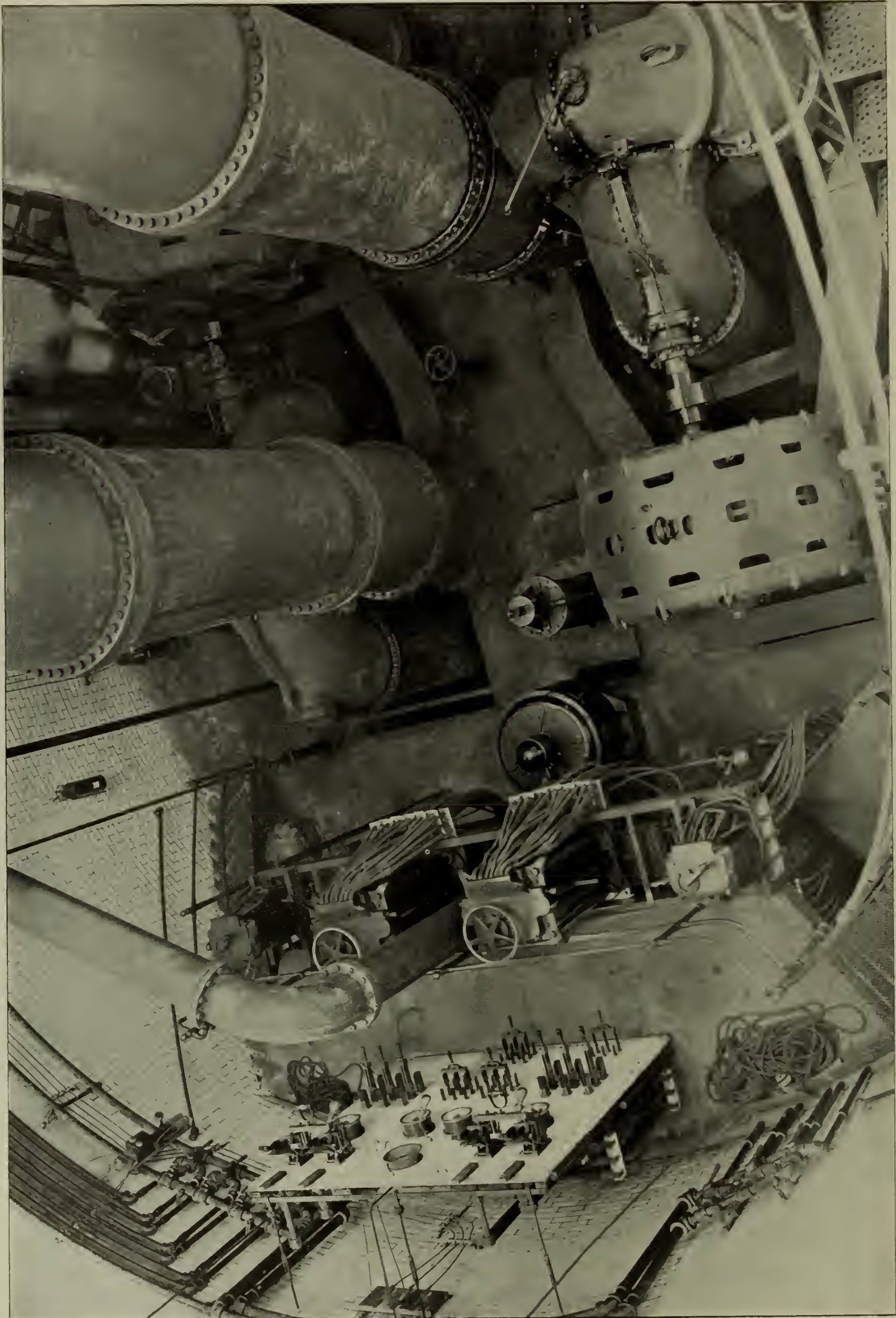


FIG. 2.—LOOKING DOWN INTO THE PUMP WELL OF THE BOSTON DRY-DOCK PUMPING PLANT. THE TWO MAIN PUMPS ARE 48-INCH CENTRIFUGALS, AND TWO 12-INCH CENTRIFUGALS ARE USED FOR DRAINING. A 5-STAGE PUMP SUPPLIES THE HYDRAULIC VALVES. ALL THE PUMPS ARE DRIVEN BY WESTINGHOUSE INDUCTION MOTORS

main pumps is shown directly below the stairway railing, with its large discharge pipe in the right-hand corner of the illustration; the other 500-H. P. pump is partially hidden from view by its discharge pipe. One of the 75-H. P. vertical motors is shown just in front of the controllers, the other being barely visible at the extreme right. On the controller stand the two outfits in the center govern the main 500-H. P. pumps, the other two taking care of the drainage pumps. One of the 375-H. P. transformers is shown just at the bottom of the stairs.

Fig. 5 shows the motor of one of the 500-H. P. pumps. Each of these pumps has a rated capacity of 65,000 gallons per minute, the normal speed of the motor and impeller being 350 revolutions per minute. Each pump and motor, with the exception of the vertical shaft drainage pumps, are mounted on a common cast-iron bedplate, with shafts connected by a flanged coupling. Provision is made for cooling this bearing in each of the two larger units by a stream of water taken from the pump discharge pipe, as shown in the lower right corner of Fig. 2.

The two large main pumps working together thus can deliver 130,000 gallons of water per minute, a performance which would empty dock No. 2 in about two hours and twenty minutes. Pending the installation of additional generating machinery in the power plant, only one of the large centrifugals can be operated at one time, which empties dock No. 2 in a little less than five hours. The old dock, No. 1, which is much smaller than the new one, can be emptied by a single 500-H. P. pump in about an hour and a quarter. The main pump motors are started on 33 volts by means of auto-transformer taps brought to the controller stand. There are nine steps of about 20 volts each in the control.

One of the 75-H. P. motors driving a culvert and pit drainage pump is shown in Fig. 4. The 12-inch centrifugal which this motor operates is located 19 feet below the motor in the bottom of the pit. All the pumps, except the five-stage outfit, were built by the Morris Machine Company, of Baldwinsville, N. Y. The 5-stage pump is of the Worthington type and is shown in Fig. 3, with its horizontal driving motor at the left. This pump draws fresh water from the vertical tank at the right, and, running at 1700 revolutions per minute, delivers it to the valve piping and system at a pressure of 200 pounds per square inch. The valve piping and controlling levers

FIG. 3.—A 5-STAGE MOTOR-DRIVEN WORTHINGTON PUMP SUPPLYING WATER AT 200 POUNDS PRESSURE FOR OPERATING THE HYDRAULIC VALVES

are shown in Fig. 2 at the rear and side of the switchboard. All the valves were supplied by the Ludlow Manufacturing Company, of Indian Orchard, Mass.

The piping system of the plant is arranged to give as much flexibility as is possible in its operation. The installation is essentially one for low pressures and large volumes. Either of the main pumps can be operated to pump out either dock; both can be applied to the same dock, or one pump can be run on one dock and the other pump on the other dock. Provision is made in the piping to take care of a third dock by this plant should one be built in the future. In the bottom of the well four 60-inch mains controlled by four 60-inch hydraulic valves enter the well, bringing the water from each dock. These are cross-connected by large T's to give the operating flexibility referred to. A pair of 38-inch riser pipes lead to each of the main pumps on the floor above, as shown in Fig. 2. Each of the latter discharges centrally into a 48-inch delivery pipe, which rises vertically through the well, increasing in diameter to 54 inches at the top of the run, whence the water is discharged into the harbour at an elevation of 26 feet above the floor of the dock No. 2.

The pump well and culvert drainage pumps discharge each into a 12-inch riser, which joins in a 16-inch discharge main at the upper level of the well. The drainage pumps are as flexibly arranged as the main pumps. The culverts themselves are 8 feet in diameter, and are built of concrete. They are carried to openings in the dock floors. Dock No. 2 is barred by a floating caisson, and

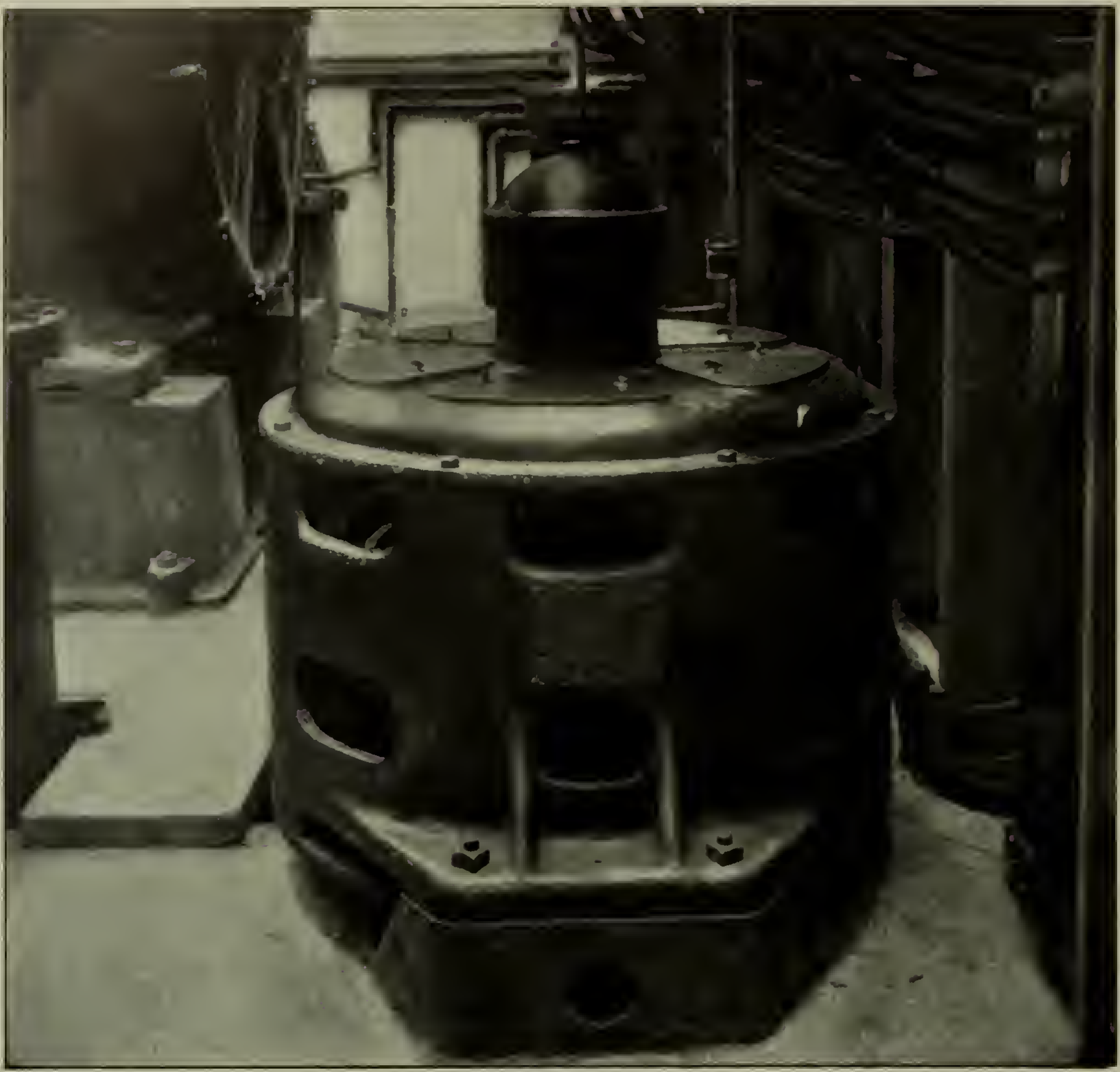


FIG. 4.—A 75-H. P. VERTICAL MOTOR DRIVING A DRAINAGE PUMP

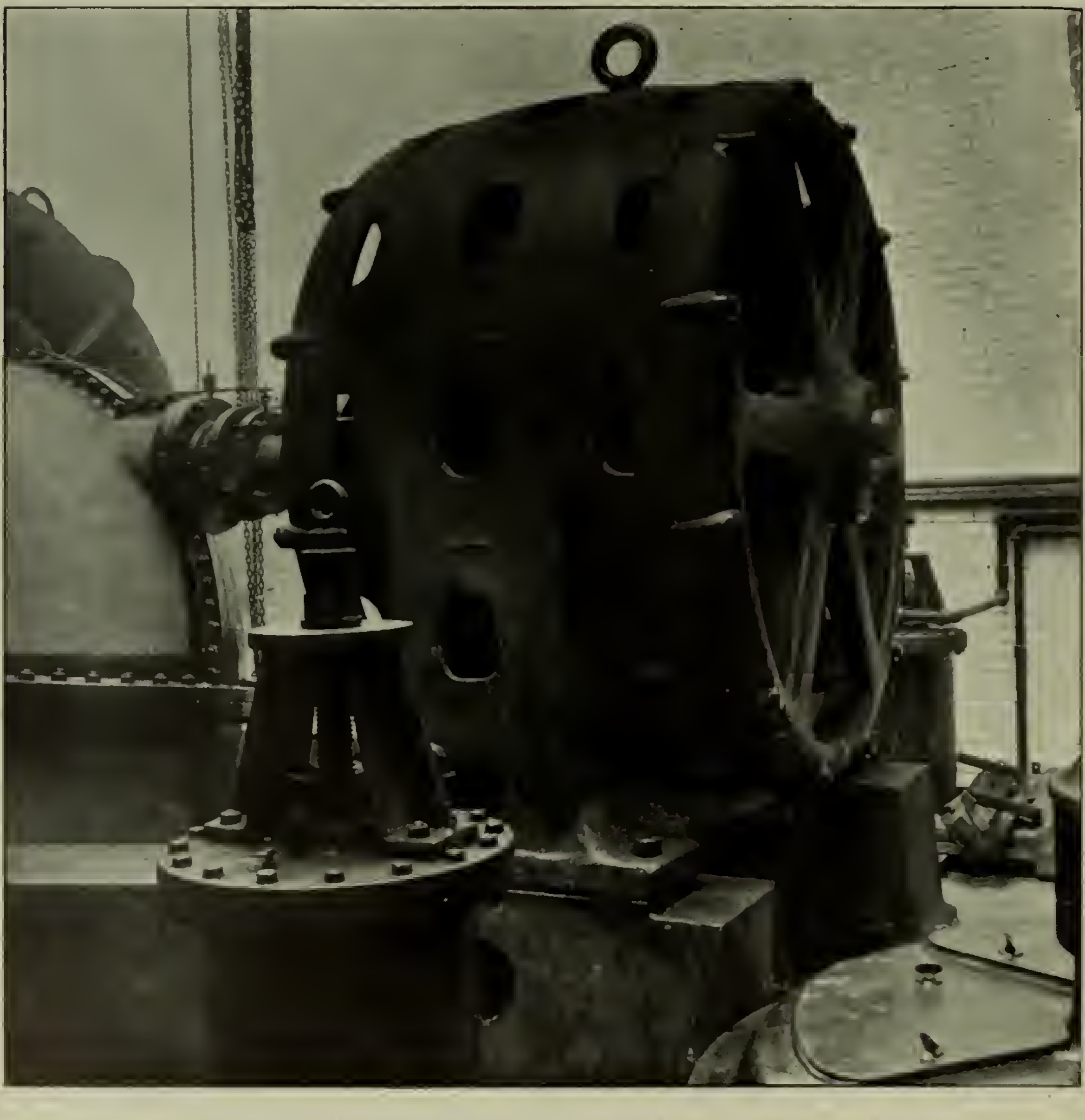


FIG. 5.—A 500-H. P. WESTINGHOUSE INDUCTION MOTOR DRIVING A MAIN PUMP

the entrance is 100 feet wide. All the main pipes are of cast iron.

Dock No. 1 is served by three 15-H. P. capstan motors, and dock No. 2 has six 10-H. P. and three 35-H. P. motors, all Westinghouse type "C," 220 volts. These motors are set up in pits around the sides of the dock and are directly controlled from these points, although the current supply comes from the 220-volt bus bars of the pump well switchboard.

On account of the dampness in the pump well, two 10-K. W. transformers were installed and connected to deliver three-phase current at 10 volts to an auxiliary set of bus bars behind the switchboard. Double-throw switches on the front of the panels enable all the motors to be thrown upon this circuit when they are not in use, for the purpose of drying out any moisture which might otherwise accumulate.

The installation is essentially one for the induction motor, for it is very doubtful if any commutator motor of less than extraordinary design could withstand the dampness which the installation presents intrinsically. The operating flexibility, simplicity and economy in comparison with steam-driven machinery should be markedly in favour of the present equipment.

Communication between the pump well and the yard is had by the regular telephone system in service there, but between the dry dock and the pump well, signals are transmitted by the engine telegraph used in shipboard communication between the wheelhouse and the engine room. The absence of long steam mains or special boiler and engine plant at the pump well and the compactness of the installation are additional features of interest. A visit to the Boston yard will well repay any engineer interested in the application of electricity to dry-dock service.

It is reported that the Allgemeine Elektricitäts Gesellschaft, of Berlin, are at present engaged in equipping the rolling mills of the Hildengardenhütte, in Teschen, with electric motors of a maximum output of 10,000 H. P., and some rolling mills belonging to the Staatseisenbahn-Gesellschaft, at Budapest, with 12,000 H. P. motors. The same firm is also providing the electric drive for the reversing mills of the Rombacher Iron Works. These reversing rolling mills are to be directly-driven by two 6500-H. P. motors, and during the first part of the rolling operations the motors have to reverse six or seven times in a minute.

The Choice of Frequency for Induction Motors

By R. E. HELLMUND

MOST engineers, in treating the question of whether high or low frequency should be chosen for a certain electric power plant, take it as an established fact that the low-frequency induction motor is far superior to one designed for high frequency. In consequence of the great number of factors which determine the excellence of an induction motor, it is, of course, impossible to draw any conclusions which hold quite generally.

The following considerations, in which the writer has endeavoured to take every factor of importance into due account, will show, however, that although it is theoretically true that the low-frequency motor has some advantages over the high-frequency type, they are not so very considerable, there being also points in regard to which the high-frequency motor is better. It will also be brought out that in actual practice under the present conditions for the larger number of cases, the high-frequency motor should even be preferred.

The magnetizing current of an induction motor is approximately proportional to the air gap density and inversely proportional to the turns per pole. The turns per pole are equal to the total number of turns over the number of poles. Therefore we may write:—

(1) Magnetizing current is proportional to

$$\frac{\text{Air density} \times \text{number of poles.}}{\text{Total number of turns.}}$$

The flux per pole of any alternating-current apparatus is inversely proportional to the total number of turns and the frequency, the potential and the winding coefficient being assumed to be constant for the present purpose. We may thus write:—

(2) Flux per pole is proportional to

$$\frac{1}{\text{No. of turns} \times \text{frequency.}}$$

The air gap density is, of course, proportional to the flux and inversely proportional to the pole face, therefore

$$(3)\ \text{Air density} = \frac{\text{Flux per pole.}}{\text{Pole face.}}$$

By introducing the value from (2) into (3), we obtain

(4) Air density is proportional to

$$\frac{1}{\text{Pole face} \times \text{frequency} \times \text{No. of turns}}$$

and by introducing this into (1), we get

$$(5)\ \text{Magnetizing current} \propto \frac{\text{Number of poles.}}{(\text{No. of turns})^2 \times \text{frequency} \times \text{pole face.}}$$

In order to avoid complicated mathematical derivations, let us consider one instance and compare a motor of a certain frequency with a motor of half this frequency having the same rating. The results obtained from this comparison will be true in general.

If we assume for the first the same magnetizing current for both motors, we see that the product

(6) $(\text{Number of turns})^2 \times \text{pole face} = \text{a constant}$, since the value $\frac{\text{Number of poles}}{\text{Frequency}}$ is constant, if the synchronous speed of both motors is the same.

If we have in the high-frequency motor a certain number of total turns, they will be distributed over a certain number of pole faces. The number of pole faces of the low-frequency motor is only half as much, and, naturally, it will not be possible to locate the same number of turns at half the number of pole faces of the same size.

Therefore, it will be necessary to make the pole faces of the low-frequency motor larger and the number of turns smaller than in the motor for high-frequency.

If we have for the high-frequency motor,

$$\text{pole face} \propto 1$$
$$\text{number of turns} \propto 1$$

we will have to choose for the low-frequency motor about the following values in order to fulfill condition (6), and in order to have sufficient room for locating the turns:—

$$\text{Pole face} \propto 1.5$$
$$\text{Number of turns} \propto 0.815.$$

According to condition (6), we have

$$1^2 \times 1 = (0.815)^2 \times 1.5.$$

The most favourable proportion of width of iron core to polar pitch will not be very much different for the two motors, and, therefore, may be assumed to be approximately the same in both cases. Under this assumption,

$$\text{Length of wire per turn} \propto \sqrt{\text{pole face}}.$$

This means that the length per turn in the low-frequency motor will be $\sqrt{1.5} = 1.225$, if that of the high-frequency motor is 1.

The weight of copper in the high frequency motor $\propto$ length per turn $\times$ number of turns $\times$ cross-section $= 1 \times 1 \times 1 = 1$.

In order to get the same weight in the low-frequency motor, we have to make the cross-section

$$= \frac{1}{0.815 \times 1.225} = 1$$

that is, the cross-section will be the same in both cases.

We know the resistances are proportional to the length of turn multiplied by the number of turns divided by the cross-section, therefore, we obtain for the high-frequency motor

$$\text{Resistance} \propto \frac{1 \times 1}{1} = 1,$$

and for the low-frequency motor

$$\text{Resistance} \propto \frac{1.225 \times 0.815}{1} = 1$$

which means that the resistances are the same in both motors. This applies to the resistances of both members.

The primary current is the same in both cases, therefore we obtain the same primary copper losses in both motors. The secondary currents are also the same in both motors, since the ratio of transformation is the same, therefore the secondary copper losses are also equal in both motors.

The eddy losses in the iron are mostly a comparatively small part of the total core losses. Therefore, the total core losses may be roughly considered to be hysteresis losses. The latter are proportional to the frequency, to the 1.6th power of the core densities and to the weight.

The weight may be assumed to be the same for both motors. We may put the weight $\propto$ number of poles × core width × core depth × polar pitch.

The same weight is, therefore, obtained, if we have in the high-frequency motor,

core width = 1
core depth = 1
polar pitch = 1,

and according to the larger pole face in the low-frequency motor,

core width = $\sqrt{1.5}$
polar pitch = $\sqrt{1.5}$
core depth = 1.33.

Therefore, the cross-sections in the core will be $1 \times 1 = 1$ and $\sqrt{1.5} \times 1.33 = 1.63$, respectively, and the densities

$$\propto \frac{1}{1 \times 1 \times 1} \propto 1$$

in the high-frequency motor, and

$$\propto \frac{1}{.5 \times .815 \times 1.63} \propto 1.51,$$

and the core losses $\propto 1 \times 1^{1.6} \times 1 = 1$ in the high-frequency motor, and core losses $\propto .5 \times 1.51^{1.6} \times 1 = 1$ in the low-frequency motor.

As will be seen, all the losses in the two motors are equal; therefore, the efficiency will be the same.

Now it may be shown that part of the leakage (slot and zigzag leakage) is reversely proportional to the size of the pole face, and part of its end connection leakage reversely proportional to the square root of the pole face.

If we assume that the leakage of the high-frequency motor is 5 per cent. and that only zigzag and slot leakage exists, we would have

$$\frac{5}{1.5} = 3.34 \text{ per cent.,}$$

and if we assume that only end connection leakage exists, we would have

$$\frac{5}{\sqrt{1.5}} \times 4.10 \text{ per cent.}$$

for the low-frequency motor. This means that a fair value for the low-frequency motor is 3.75 per cent.

Before finding from this a comparative value for the power factor, we may remember that for the determination of the magnetizing current only the air-gap reluctance has been taken into account. Since, however, higher densities and longer iron paths have been assumed, the magnetizing current in the low-frequency motor will be about 1.1, if that of the high-frequency motor is 1.

It may be easily found that under these conditions in almost all cases within practical limits, the full load power factor of the two motors shows hardly any difference, and that, therefore, in this particular case the only advantage of the low-frequency motor is the higher overload capacity for instantaneous loads and the better starting torque.

At the same time, however, it may be shown that the cooling surface of the low-frequency motor is much smaller, and that, therefore, its overload capacity for continuous overloads is much lower than that of the high-frequency motor, the losses being the same in both cases.

Of course, it is possible to improve the full load power factor of the low-frequency motor. This, however, requires a larger number of turns, and assuming the amount of material to be constant, the copper losses will thereby be increased considerably, and although the iron losses decrease, the total losses increase, and, therefore, the efficiency decreases almost as much as the power factor may be increased. Moreover, the starting torque and the maximum output for instantaneous and for continuous overloads decrease, so that in most cases hardly any advantage may be secured by such changes. It seems to the writer that it is never advisable to secure an improvement in the power factor at the cost of the efficiency, if the product of these two factors cannot be considerably improved thereby.

It might be said that since the diameter of the low-frequency motor is smaller, the air gap may be made shorter and thereby some advantages secured. It must be taken into consideration, however, that the motor is wider, and, therefore, a longer shaft is required, and that the motor works with a stronger total field, therefore a shortening of the air gap is hardly advisable.

Another fact that may be mentioned is that since the frame of the low-frequency motor has a smaller diameter, it will be lighter and cheaper. This will be compensated, however, by the fact that its core is wider, and the cost of making up the discs will, therefore, be increased.

Reviewing now the previous considerations, we may say that if motors are built at the same cost for high and low frequency,—60 and 30 cycles,—the low-frequency motor will be superior in regard to starting torque and overload capacity for instantaneous overloads, but inferior in regard to overload capacity for continuous overload, while hardly any advantage in regard to efficiency, power factor or apparent efficiency may be secured. This is under the assumption that both motors can be built for the same speed and each designed as favourably as possible. The two latter conditions are, however, almost never fulfilled in actual practice.

As is well known, all motors are cheaper the higher their speed. In actual practice the highest admissible speed is mostly given for some reason or other, and the motor is built for the next lower possible speed. The standard frequencies in this country are 25 and 60 cycles. Therefore, we have the following table:—

Highest Speed Admissible	Next Lower Speed Possible 25 Cycles	60 Cycles
2.000	1,500	1,800
1,900	"	"
1,800	"	"
1,700	"	1,200
1,600	"	"
1,500	"	"
1,400	750	"
1,300	"	"
1,200	"	"
1,100	"	900
1,000	"	"
900	"	"
800	"	720
750	"	"
700	500	600
650	"	"
600	"	"
550	"	514
500	"	450
450	375	"
400	"	400
350	300	327
325	"	"
300	"	300

Comparing the motors for admissible speeds from 2000 to 1000, we find that on an average the speed of the 60-cycle motors will be 13 per cent. higher than that of the 25-cycle motors; for the lower speeds the average difference is 8 per cent. This, of course, will cause some difference in the average prices in favour of the high-frequency motors.

Of highest importance is the fact that most plants are mixed light and power plants, and, therefore, most induction motors are, in this country, by necessity, 60-cycle motors. The manufacturer, therefore, sells more 60-cycle motors than 25-cycle, and is, as a rule, especially anxious to make his 60-cycle motors good and cheap. Since it would not pay for him to make a special type for 25 cycles, he simply uses the 60-cycle type, with special winding for 25 cycles, and under very unfavourable conditions of design.

The consequence therefrom is that the standard motors on the market for 25 cycles, although somewhat better in regard to starting torque, instantaneous overload capacity, and often also somewhat better in power factor, are, in regard to overload capacity for continuous overloads, their commercial efficiency, and their apparent efficiency (this value and not the power factor is important for the line losses), mostly worse than in 60-cycle motors, or the 25-

cycle motors are considerably higher in price.

According to these facts, it seems to the writer that the European practice is preferable to the practice of this country. In well-designed motors some advantages may be secured by using low frequencies. The standard frequency in Europe is as low as admissible for lighting purposes, that is, 50 cycles, and this frequency is used in almost all cases, even where current for power alone is generated. In contradistinction to this, all manufacturers in this country have to carry motors for 25 and 60 cycles in stock, and the advantage thereby secured is, perhaps, only imaginary, especially since it is, as a rule, not difficult to design motors for 50 or also 60 cycles, with a starting torque and instantaneous overload capacity which are sufficient for most requirements in practice.

Of course, the writer is aware that there are certain cases in which the low-frequency induction motor is far superior to the high-frequency motor; for instance, in cases where low-speed motors have to be used, where especially high-starting torque is required, and also in such cases where only a few very large motors, which are especially designed for the purpose, are operated by a long-distance transmission. Low frequency is especially adapted for railroad purposes, etc.

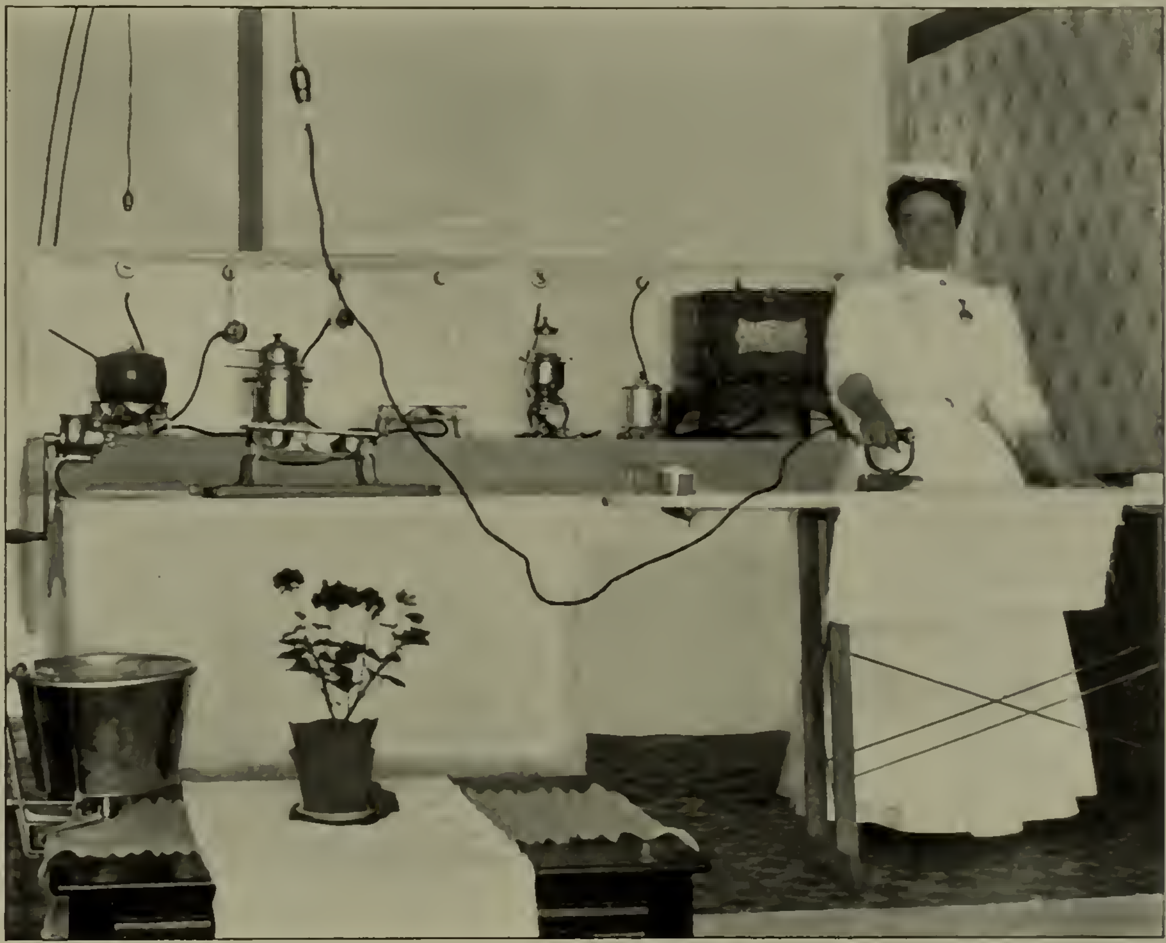
The writer is also aware that the induction motors operated by a certain plant are not the only factors which influence the choice of the frequency. It is believed, however, that in almost all cases where light and power are needed it is not advisable to use two frequencies, that is, 60 cycles for light and 25 cycles for power, as has been proposed and done in many cases, but that it is much more economical to use the high frequency for both purposes.

A novel scheme has been instituted in England for hiring out accumulators for ignition sets to automobile and motor-cycle owners. By the payment of a small sum, subscribers are provided with an official pass which allows them at any time to exchange their run-down ignition accumulaters for fresh ones at any station along the route. Three distinct classes of motorists are catered to,—motor-cyclists, small-car owners and four-cylinder-car owners. The first-named are, perhaps, the most benefited by the innovation, as the ignition accumulator is one of the motor-cycle's weak points.

Progressive Business-Getting Methods

In the June number of The Electrical Age, under the heading of "Up-to-date Methods of Getting New Business," was described the methods adopted by T. C. McReynolds, secretary and teasurer of the Kokomo, Marion & Western Traction Company, for increasing the sale of current for domestic use.

Mr. McReynolds, who is also connected with the Noblesville Heat, Light & Power Company, has adopted the same plan at Noblesville for increasing the current sales. The annexed illustration shows the arrangement of the apparatus which was used by Mrs. F. V. Sanborn to demonstrate cooking by electricity at the daily lectures.



ELECTRICAL COOKING APPARATUS IN THE DEMONSTRATING HALL OF THE NOBLESVILLE HEAT, LIGHT & POWER COMPANY, NOBLESVILLE, IND.

Folders were sent out, on the front of which was printed the following invitation:—

ANNOUNCEMENT

The Noblesville Heat, Light and Power Company
invite you to
Attend a course of lectures on
Cooking by Electricity,
by
Mrs. F. Violet Sanborn,
the well-known lecturer and writer
on Domestic Science, at
Second Room South of Opera House,
Beginning Monday, May 7.
Daily, 2.30 P. M.
No Charges or Collections.

Inside the folder was the following:—

AN OPPORTUNITY

For every lady to acquire a thorough
knowledge of the comfort, convenience and economy of

ELECTRICITY AS FUEL.

To witness actual demonstration of
the results obtainable, and to procure
recipes of the daintiest dishes.
Mrs. Sanborn will teach you to cook
economically with electricity.

A weekly menu was also printed, which is given below, with the cost of cooking each dish, and the total for each day.

MENU FOR NOBLESVILLE

Daily, 2.30 P. M.

	Cents
Monday—Cost 10 cents	
Currant bread	3
Broiled porterhouse	1½
Fruit nut bread	3½
Paul Jones Indian pudding	1
Velvet biscuit	1
Coffee mussee	
Tuesday—Cost 7 cents	
Fancy salads	2½
Golden mayonnaise	1½
Cheese balls	1
Ribbon salad	2
Vinegar test	
Wednesday—Cost 7½ cents	
Flank steak a la creole	1½
Nut bread	3
Cheese custard	1
Fruit salad	2
Ice cream croquettes	
Thursday—Cost 9½ cents	
Broiled chops	1½
Spiced rolls	2
Milk bread	3½
Strawberry short cake	1½
Pineapple salad	1½
Yeast test	

Friday—Cost 9 cents

Veal birds, mushroom sauce	2
Planked fish	2
Fruit bread	$2\frac{1}{2}$
Angels on horseback	1
Love apple salad	$1\frac{1}{2}$
Wedding mussee	

Saturday—Cost $8\frac{1}{4}$ cents

Strawberry mousse with whipped cream	$1\frac{1}{2}$
Golden layer cake	$2\frac{1}{2}$
Berlin salad	2
Broiled steak	$1\frac{1}{2}$
Coffee au lait	$\frac{3}{4}$

Saturday, 8 P. M.—Cost $8\frac{1}{4}$ cents

Broiled tenderloin	$1\frac{1}{4}$
Chicken recheffe	$2\frac{3}{4}$
Potato bread	2
Shredded ham with currant jelly	$1\frac{1}{2}$
Angel parfait	1
Coffee	$\frac{5}{8}$

The cost given is obtained by finding the current consumed as indicated by a meter with a rate of four cents a kilowatt-hour.

At the lectures, the company's representative exhibited the cooking utensils, and these, with flat-irons, have been placed on trial, and are proving successful in convincing the users of their convenience and economy. Exactly the same methods are being used at Noblesville as have already proved successful at Kokomo, and the results indicate that the current sales will be largely increased.

May Meeting of the New York Electrical Society

At the May meeting of the New York Electrical Society, held at the Edison Auditorium, two papers were read dealing with the problem of transportation. Max E. Schmidt discussed "The Moving Platform Railway in City Transportation," and F. B. Behr dealt with "The Mono-Rail Solution of the Rapid Transit Problem."

Mr. Schmidt first described the elevated railway proposed in 1847 on Broadway, in New York City, the moving platform idea first being brought out then. An experimental line was built, the capital being provided by William Astor, Peter Cooper and others. This line, however, was destroyed by fire.

The moving platform at the Chicago Exposition, in 1893, and that at the Paris Exposition, in 1900, were next described. He showed also the construction of the proposed moving platform to run under Thirty-fourth street, New York City, from First to Ninth Avenues.

Among the advantages which Mr. Schmidt claimed for passenger transportation by means of the moving platform were the following:—

1.—Absence of congestion, as the masses of people do not stop.

2.—The carrying capacity is greater than on a railway. A load of 900 tons requires 60 H. P. to travel at six miles an hour.

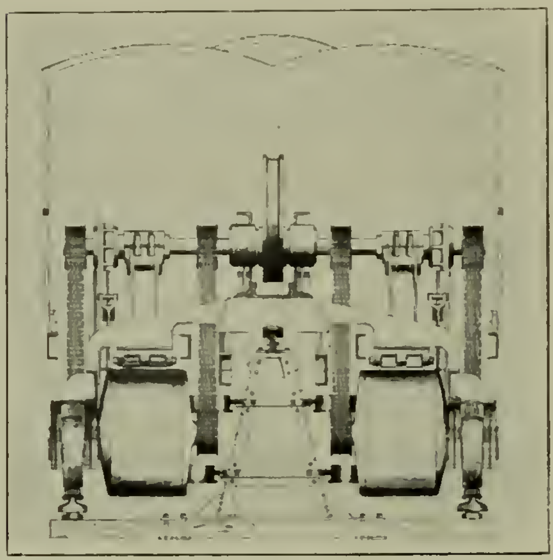
3.—The cost of operation is small, owing to the lack of heavy traction equipment. The driving mechanism is protected from the weather, and thus has a long life. No motormen or conductors are necessary.

4.—Absence of stops and starts.

5.—Low rolling friction.

A moving picture was shown of the moving platform at the Paris Exposition in 1900. The paper was concluded with a description of the moving platform proposed by Geo. S. Morrison for the Brooklyn Bridge.

Taking up the mono-rail system, Mr. Behr first described his proposed line for New York City. Starting at Van Cortlandt Park, it would run south to Seventy-fifth street, where it would branch east to the Borough of Queens, thence turning south through Flatbush to Fort Hamilton, crossing the Narrows to Staten Island, and ending at Tottenville. From Seventy-fifth street, also, a line would run to the City Hall and cross the East River to Brooklyn, where it would intersect the other line at Flatbush, and continue on to Coney Island.



CROSS-SECTION OF A CAR, SHOWING THE DRIVING MECHANISM OF THE BEHR MONO-RAIL SYSTEM

From Tompkinsville to Van Cortlandt Park is a distance of 37 miles, which would be covered in 38 minutes. From Coney Island to the City Hall would require 11 minutes, and from Tottenville to the City Hall, 25 minutes.

The system would have four tracks, two for a speed of 15 miles an hour and two for 60 miles an hour. The express stations would be $3\frac{1}{2}$ miles apart.

The system has been in use in Ireland for the past eighteen years, and a line between Manchester and Liverpool is now under way. An illustration of the driving gear is given on this page. Each car has four vertical wheels, which run on the mono-rail. Two of them are driving wheels, 4 feet 4 inches in diameter, and the other two are trailers, 3 feet 5 inches in diameter. The wheels are 5 inches wide, and each has a central groove 2 inches deep and 3 inches wide.

The centre line of the motor shafts is 4 feet $6\frac{1}{2}$ inches below the centre line of the driving-wheel axles, and connection between them is made by chain drive. The two motors at each end of the car are connected to one driving wheel. The power required during acceleration is 279 H. P. per motor, and with normal current it is 129 H. P. per motor. Current will be supplied by means of two conducting rails, one on each side of the trestles near the ends of the ties.

The distance between Manchester and Liverpool is $34\frac{1}{2}$ miles, and it is proposed to cover this in 20 minutes. The British Board of Trade has set the speed limit at 110 miles an hour.

Among the advantages claimed by Mr. Behr for his system are that a higher speed can be attained, that the grinding action on curves is avoided, curves of shorter radius can be built, and the cars can climb steeper grades.

Passenger traffic in New York City owes its tremendous growth to the application of electricity in this direction. According to the report issued by the State Railroad Commission, 297,339,165 passengers were carried during the three months ending March 31, 1906. This is an increase of 37,061,250, or $14\frac{1}{4}$ per cent. The number of surface transfers issued during this time was 68,212,755, an increase of 10,822,871. The car mileage was 56,998,216, a gain of 6,522,434. While the surface and the elevated lines have recovered from the effect which the opening of the subway had upon them, the last-named carried 41,000,000 during the quarter.

The New York Electrical Club has leased commodious apartments at 14 and 16 Park Place. The club starts with a membership of 150, and during the reception many gentlemen identified with the allied electrical interests were present. In the suite of rooms are included a fine dining hall and a private dining room, which promise to become popular among the electrical men. Reasonable prices will be charged.

Nuggets from the Milwaukee Convention

Of the American Institute of Electrical Engineers

In a synchronous converter the ratio of the voltages at the terminals of the two sides of the machine is approximately constant, and independent of the load on the machines or the magnitude of the excitation. So the only way of varying the direct-current terminal voltage is to vary the alternating-current voltage supplied to the machine.

Assuming that approximately constant voltage is supplied at the generator end of the alternating-current feeders, and that the circuit between the generator and synchronous converters contains sufficient inductance, then the voltage at the synchronous-converter end of the alternating-current line can be raised or lowered by introducing a leading or a lagging current into the system. A leading or lagging current can be introduced into the system by over or under-exciting the converter. So by putting a series winding on the magnets of the converter the excitation of the machines will be increased as the load comes on, and a leading current approximately proportional to the load introduced in the alternating-current system. This will tend to raise the alternating-current voltage supplied to the converter, and, in consequence, the terminal voltage at the direct-current side.

Here, then, is a system that gives automatic control of the voltage as the load varies. Unfortunately, this system presents a number of disadvantages in practice; a series winding is needed on the converter magnets, artificial reactance coils are practically always needed to insert in the alternating-current line so as to bring its reactance up to the required value, and there is need for extra switchboard arrangements. This means increased complication and cost, and a loss of efficiency. A compound-wound converter costs about 7 or 8 per cent. more than a shunt-wound converter. Reactance-coils usually cost about 5 per cent. of the cost of the converter. The efficiency of the system is lowered probably 1 to 2 per cent. In addition the system is more complicated, and in consequence more liable to break down. There is also liable to be trouble in operating the system. A series field winding on a synchronous converter is always a source of danger on account of the liability of its reversing. * * *

The automatic compounding obtained by a series winding and reactance coils is not so satisfactory as would be expected. * * * This method of compounding is often a nuisance. There must be careful adjustment of the series winding and of the resistance coils at the sub-stations before getting the desired effect. If other compound-wound converters are installed in the same sub-station, there is trouble to adjust them so that they divide the load properly at all loads. If shunt-wound converters are not dividing the load properly, varying the field rheostat will quickly adjust the load. * * * A shunt-wound converter tends to keep the power-factor the same at all loads. * * *

Thus with shunt-wound converters instead of compound-wound machines with reactance-coils, there results a cheaper, more efficient, and less complicated outfit, an outfit less liable to give trouble, and which will give better results both in large and in small stations.—*W. L. Waters.*

The chief requisites in church lighting are adequacy and uniformity. The maximum variation throughout the auditorium should not exceed 20 per cent. This uniformity is seldom secured with daylight, but there is no reason why it should not be attained with artificial light, since electricity can easily be transmitted to all parts of the building and practically moulded to suit the demands of distribution as well as the needs of the architecture and decoration. In this respect the electric light may be said to "beat daylight."

The amount of light in the reading plane should not be less than two candle-feet, that is, about twice the light required by the average person for reading without the impairment of eyesight. The frugal vestryman may ask, "Why double the amount of light?" The answer is that the best and most attractive lighting is not only an excellent advertisement and a means of grace, but it may be quite economically employed in assembly rooms which are occupied but six or eight hours each month, if the controlling devices be properly designed and used.

Furthermore, a religious gathering, more than any other concourse of people, contains persons of all ages, many of whom have failing eyesight, and all of whom should have sufficient light to enable them to read the lines of text or hymn. With an expense of $2 an hour for light which gives perfect satisfaction to everyone in the audience, and makes of the auditorium a beautiful and attractive place for young people, there can be no question of extravagance. The extravagance lies rather in employing a system which, although it may cost half as much, fails to give satisfaction to any considerable number of the congregation.—*Edwin R. Weeks.*

It is known that disturbances are caused on a system by allowing too large a flow of current across arresters; therefore, the requirement that an arrester should take a limited amount of dynamic current naturally suggests itself. The writer considered that a three-ampere fuse wire placed in series with the arrester should not be melted on the discharge of a static machine across the gaps to start the dynamic arc. With this requirement in view, tests were made to see how many gaps would have to be placed in series properly to limit the current. During the test, gap after gap was added until forty-eight gaps from line to line were used before the current was properly limited. A consideration of the expense and size of this arrester showed immediately that it would be uncommercial.

Experiments were then conducted to see how the number of gaps could be reduced by the use of resistance in shunt to some of the cylinders. It was found that nine gaps, with six of them shunted by carborundum resistance, would limit the current to the proper amount so as not to blow a three-ampere fuse. Usually there will be two such combinations in series, giving eighteen gaps from line to line with twelve of these shunted by resistance. Making further tests on this arrester, it was found that low-voltage discharges from a Leyden jar would pass through the series gaps and resistance, but high-voltage discharges would pass through all the gaps, thus producing an arrester which allows a direct discharge across the gaps to ground without taking too large a dynamic current. It is realized that the lightning discharge itself may give a spark across the gaps which will allow greater dynamic current to flow than during the Leyden-jar test. The amount of lightning current can be determined only by actual tests on lines. Five hundred of the multigap arresters with shunt resistances for 2200-volt circuits were placed in service last season and operated practically without trouble.—*H. C. Wirt.*

Some of the forms of lightning stroke cannot be reproduced in the laboratory. Laboratory demonstrations have often been made of one particular kind and power of stroke in conjunction with a device which protects against that particular condition, but not against a number of other conditions met in practice. As a result, laboratory methods have fallen into disfavour and disuse. This condition is unfortunate, in that apparatus may be installed which is intrinsically unable to withstand even laboratory tests.

It seems safe to adopt a rule used in the development of protective apparatus, to the effect that all protective apparatus must pass the laboratory and shop tests before it can be considered ready for the line test; it seems safe to say that, sooner or later, the arrester installed on the line will be placed under every reasonable condition that can be produced in the laboratory test, and besides, it will be subjected to other strains arising from new conditions, such, for example, increased static capacity, distributed capacity, and inductance, increased kilowatt capacity of generators, auxiliary oscillations, reinforcement of higher harmonics, disintegration from brush discharge, depreciation from use, bugs, dirt, and so on.

At the same time, all the elements are present on the line which could produce the effects of the laboratory tests. For example, although the total distributed capacity and the total inductance of a transmission line may be such as to give a low value of proper frequency, a higher frequency is possible by segmental oscillations on the line, as on a violin string; or a local circuit may be formed of small capacity and inductance, or high frequency may come from a neighbouring spark, an arc, or cloud lightning.

The range of frequency which must be considered in lightning protection lies between zero frequency (direct current) to about one billion cycles per second. Within this range there are certain values of frequency which may be counted on as absent; such, for example, are the frequencies lying between zero and the generator periodicity, and also those frequencies lying between the odd multiples of the generator frequency extending over a considerable range above the normal frequency.

The quantities of electricity involved vary from an immeasurably small quantity, through the range of comparatively small quantities tied up at different points of the transmission circuit in the form of electromagnetic and electrostatic energy, into the range of comparatively large quantities involved in line-current flow over an arrester subsequent to the passage of the electrostatic spark. Up to the time the line current starts, the energy involved is inconsiderable, but the power is usually enormous. The successful arrester must be arranged to discharge this energy at its natural maximum rate of discharge. Any restriction of power increases the risk of high-potential strains.

On the other hand, when generator current follows, the almost incompatible condition of restricted power and energy must be introduced. To summarize:—The factors of immediate interest are the rise of potential, the quantity of lightning electricity, the proper frequency of discharge, the frequency of recurrence of the lightning stroke, the power of the lightning stroke, the power and energy of the generator discharge.—*E. E. F. Creighton.*

The following are the principal points brought out relative to two and three-phase motors, and will aid the designer in deciding upon the proper ratings for machines when wound for two-phase service:—

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 two and three-phase machines, when expressed in per cent. 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 the three-phase machine.

Even machines of the same phase and rating, which are made as nearly alike in every respect as is commercially possible, vary widely among themselves in their characteristics when put in test. This fact makes it very difficult to determine by test the relative behaviour of two and three-phase machines, especially with regard to those characteristics which differ but slightly.

There can be no doubt as to the higher temperature rise of the copper in the two-phase motor, occasioned by the higher copper loss. For the same reason the efficiency of the two-phase motor is slightly lower, the difference depending upon the relative magnitude of the iron and copper losses. Since the slip is equal to the ratio of the secondary copper loss to the total power input to the secondary, it is evident that the slip is greater on the two-phase motor. Calculations and tests indicate that the slip on two-phase motors is about 20 per cent. greater than in three-phase motors. Due to the increased leakage, the power-factor on the two-phase machine is from 1 to 3 per cent. lower than on the three-phase motor.—*Bradley McCormick.*

When the fringe of the main field is used for commutating purposes, it is necessary to bevel off the edge of the pole, so that the fringe shall be sufficiently wide. In cases where the teeth of the armature are wide, it is necessary to make the bevel of the edge of the pole quite wide. This robs the pole of valuable area, tending to increase the speed of the motor. With the inter-pole construction, as the fringe of the main field is not used for commutating purposes, the beveling or skewing of the edge of the pole may be much narrower, and, therefore, the effective pole area is larger. If it were not for the humming of the armature teeth, the main pole could be rectilinear, and without bevel. If a skew form is used, it should amount to about one tooth and slot of the armature, this being sufficient to dampen all tendency to vibration of the teeth.

The inter-pole produces a much better form of commutating field than can be obtained from the fringe of the main field, even on constant-speed motors, unless an extremely wide bevel is used. This is due to the fact that the inter-pole may be made much wider than the bevel of the main pole, thus furnishing a broad, uniform field, well suited to commutating conditions. The current is, therefore, quite uniformly distributed over the brush face, and none of the difficulties such as pitting or incandescent positions of the brush, due to too narrow a commutating fringe, are experienced.—*C. H. Bedell.*

With large machines whose resistance and pure or non-iron reactance are relatively low, damage by even slightly inaccurate synchronizing will be more probable, as well as more costly, than with small machines, since the impulsive rush of current is proportionately greater. * * * It is evident that the maximum circulating current may be reduced in any desired degree by the insertion of sufficient impedance between the machines to be synchronized.

Steinmetz has shown that the synchronizing power of the current that may circulate between two machines in parallel under the normal condition of equal voltage depends upon the lagging of the current due to the inductance of the short-circuit path through the armatures of the alternators. To retain this lagging current and its desirable effect, the impedance to be connected in series between the machines should be highly inductive. The use of condensers in series confirmed the theory above outlined, for the alternators now assumed the 180-degree phase-relation, and retained it with such persistence as to suggest easy synchronizing by using a reversing switch to connect the machines together in the zero phase-relation. At this point it was proved by experiment that it was a simple matter to synchronize two alternators through the armature of a third alternator not running, and then by bringing this third machine up to synchronous speed to observe that it automatically fell into step, forming a delta-connected, three-phase system.

The oscillograph showed that with equal excitation the electromotive-force curves were properly spaced in 120-degree positions, and that by varying the excitation it was easy to obtain a distorted delta of any desired shape, within reasonable limits, giving a simple means for obtaining any required vector-difference of voltage or current, especially if one of the machines were a polyphase machine but used as a single-phaser in a delta arrangement. The connection was fairly stiff, it being possible to cut off the driving power from two of the machines, when they became alternating motors and carried their previous driving motors as load. The oscillograph showed that the experiment was successfully performed.

Having control of the synchronizing angle at the 180-degree and the 120-degree positions, we felt that some way to secure the desired 0-degree-angle must be available. A final idea of trying an inductance without any iron core came opportunely. This would secure the desired lagging current, and the pure inductance acting instantaneously would not permit an impulsive rush of dangerous value, even at maximum difference of phase. A trial met with flattering success; and by adjusting the amount of inductance, it was found that for a 7.5-KW. machine, a value limiting the maximum current to about half its full-load amperes seemed the best, having due regard to objectionable reaction upon the system, as well as to synchronizing effect.—*M. Brooks and M. K. Akers.*

The best material of which to construct a resistance thermometer depends upon the temperature range to be measured, as well as upon the physical qualities of the available materials. Constancy of composition and other practical considerations seem to limit the choice to a few of the pure metals, usually in the form of wire. The metal which has received the most study is platinum. It can be used over a very wide temperature range, and can be obtained under the name of Heræus platinum in a state of great purity.

This material answers every requirement of resistance thermometry, except that it is very costly. A substitute for platinum should, therefore, be sought and used wherever it will serve as well. This substitute should be inexpensive, and obtainable in a pure state. It is desirable that it should have a high specific resistance, combined with a large temperature coefficient. It should be unoxidizable under usable conditions, and withstand a high temperature without deterioration or permanent alteration in resistance.

An examination of the pure metals shows that these conditions are best met by nickel. The writer has had many thermometers constructed of this wire for temperatures ranging from — 40 degrees Cent. to 300 degrees or 400 degrees Cent., and has found it entirely reliable for this range. Conclusive experiments made to determine the availability of nickel for high temperatures would be very useful. Nickel has a higher coefficient than the purest platinum, it being about 0.0041 per degree between 0 degree Cent. and 100 degrees Cent., and pure platinum, 0.0039, and commercial platinum but about 0.002. The specific resistance of pure nickel and pure platinum is in the ratio of about 933 to 1000.—*E. F. Northrup.*

Vapour converters can be run in parallel under the proper conditions without difficulty. The general condition determining satisfactory paralleling is that the voltage absorbed in each of the parallel circuits shall increase at least slightly with increase in current, since this insures a division of current between the two circuits. If two devices be used in parallel of such a nature that with increase in current a less voltage is absorbed, such as mercury vapour lamps, it is evident that the more current one of these devices takes, the more current it tends to take in proportion to the other device on account of its lowered voltage.

The bulb of a vapour converter also is usually a device of this character, that is, an increase in current causes a decrease in voltage throughout the operating range. In such cases they cannot be connected in parallel directly, since one bulb or the other would instantly take all the current. By the insertion somewhere in the paralleled circuits of a sufficient amount of ohmic or inductive resistance, so that the additional voltage absorbed in the resistance on any increase in current shall be greater than the decrease in voltage in the bulb, satisfactory parallel operation is obtained. Since the voltage change on the bulb would not ordinarily be more than a volt or two, a very slight amount of resistance is sufficient to insure good operation. Obviously, the inductance may be substituted for resistance in such parts of the paralleled circuits as carry alternating or intermittent currents. * * *

A very interesting application of vapour converters is the operation of series direct-current arc lamps from a constant-current alternating supply. When a moderate number of lamps is to be operated in series a single bulb will furnish a sufficiently high direct-current voltage; where many are lamps are to be operated, two or more converter bulbs may be used, by which the direct-current voltage of the various bulbs is available in series in the arc circuit.

By the use of sufficiently powerful

sustaining coils it is possible to utilize current obtained from 25 cycles without material flickering of the arcs. This is an extremely important gain for the users of 25-cycle systems. Bulbs in series may be started as individuals and afterwards thrown in series either on short-circuit or lamp load, or they may be started on a common short circuit or even on the arc circuit itself, the connections for accomplishing this purpose being comparatively easily devised.—*P. H. Thomas*.

The points which have to be considered concerning transformers in a system of station connections are:—the number of units, rated capacity, and capacity relative to that of station generators and lines; the system of high and low voltage transformer connections, delta, star, etc., and whether grounded,—single or three-phase,—the number of taps and the number of systems at different voltages fed from the same transformer banks. * * *

The capacity of a transformer bank is preferably made that of a generator, and, if possible, so is that of the line. With many large units, this may be done. At least two transformer banks should be used, and duplicate lines fed to any substation where the continuous supply of power is essential. If a large number of generators be installed, it may be desirable to make a unit of one transformer and two generators. In other cases, the number of transformers is entirely independent of that of the generators.

If it be desired to avoid high-tension switching and the use of current transformers on the high-tension side, the transformer bank may sometimes advantageously be made a unit with the line. The transformer bank can always equal the generator capacity, but the reverse is not true. It is desirable, whenever possible, to have the transformer banks make a unit with either the generator or line.

The use of single or of three-phase transformers is a matter of building design, transportation, cost, reserve capacity, and repairs. In the case of many large units, it costs no more to have a spare three-phase unit than a single-phase, and, if a transformer-generator system be used, the disablement of a three-phase transformer is no more serious than one of a single-phase bank, unless the load be carried on two transformers. The cost can be calculated for each case, and there is always a dividing line where the relation of cost is reversed. Three-phase transformers are more difficult to transport. A reserve unit in either case is necessary.—*D. B. Rushmore*.

In inventing a machine to operate upon any given material, the logical way is to work from the tool to the power. The tool, or tools, should first be invented, and the motions determined which are to be given to them. The proper gearing of parts to produce from the power each motion for each tool should then be invented. It should then be considered if parts of each train of gearing cannot be combined, so as to make one part do the work of a part in each train; in short, to reduce the machine to its lowest terms.

Occasionally a mechanism will be invented which is exceedingly ingenious, but which it is afterwards seen how to simplify greatly at the expense of its apparent ingenuity. This simplification will be at the sacrifice of the pride of the inventor, but such considerations as cheapness, durability and certainty of action leave no choice in the matter. It will sometimes be found that a single part can be made to actuate several parts, by the interposition of elements which reverse the motion taken from such part, or which take only a component of the motion of such part, or the resultant of the motion of such part and some other part. * * *

The drawing board can be made a great source of economy in producing inventions. If the three principal views of all the essentially different positions of the parts of a machine are drawn, it will often be found that defects will be brought to light which would not otherwise have been observed until the machine was put into the metal.—*E. J. Prindle*.

Report on Telephones and Telegraphs

THE last of a series of reports on the generation and utilization of electric current for the transmission of power, messages, and conversation, recently published by the Bureau of the Census, treats of the telephone and telegraph systems and the municipal electric fire alarm and police patrol systems of the United States.

In 1902 the forty-four Bell telephone systems reported about seven-tenths of the wire mileage for all telephone systems, more than one-half of all the telephones, and three-fifths of the messages or talks during the year. They employed over seven-tenths of the wage-earners, and paid almost four-fifths of the wages.

The report shows that on the average there was 1 telephone to every 34 persons, that each person talked 65 times a year, and that each telephone was used 2190 times.

Of the 1157 cities in the United States with 4000 or more inhabitants, 1002 cities were provided with telephone systems of some kind in 1902. San Francisco ranked first, with 1 telephone to 9 persons. Cleveland ranked second, with 1 telephone for every 16 persons, and Boston third, with one for every 19 inhabitants.

The average revenue per telephone amounted to $37.50, and the average revenue per message was 1.7 cents. The average operating expense was $24.56 per telephone, and 1.1 cents per message.

According to a table giving telephone statistics up to January, 1905, the number of telephones in the United States was then 3,400,000, and in Europe, 1,485,784.

Comparing the rates charged for telegraph and telephone messages, it was found that for medium distances they do not differ greatly, but for very long distances they are overwhelmingly in favour of the telegraph, if the message be taken as a unit. If, however, the number of words exchanged be taken into account, as well as the time required for getting into communication, the telegraph is at a disadvantage in case of a large amount of traffic.

The commercial land telegraph systems of the country owned and operated 1,318,350 miles of wire in 1902. In addition, there were 16,677 nautical miles of submarine cable. Railway telegraph systems were reported in use by 684 companies. The number of telegraph messages sent during 1902, for railroad business only, was 201,743,756, and the number of commercial messages was 4,474,593.

In 1902 there were 764 electric fire alarm systems in operation. The largest number, 106, was reported for Massachusetts, and the next largest, 70, for New York. More than one-fourth of the 39,635 miles of fire alarm wires were underground at that time.

Police patrol systems numbered 148, with 26,350 miles of wire, 9476 signalling boxes, and 1170 telephoning boxes. Over these systems there was a daily average per box or station of more than 10 calls. The use of the telephone for this work predominated, there being 23,393,812 telephone messages, as compared with 17,232,693 messages of all other kinds.

The American Institute of Electrical Engineers

The Convention at Milwaukee, Wis., May 28—June 1

THE opening session, on Monday, May 28, of the annual convention of the American Institute of Electrical Engineers marked the dedication of the public auditorium of the Milwaukee Electric Railway & Light Company. The convention was not notable in point of numbers, as only about 100 members had registered up to the time of opening, and up to Wednesday evening the total registry, including ladies, was 230.

As Mayor Becker was unable to be present, City Attorney J. T. Kelley expressed the Mayor's regrets and welcomed the delegates to the city. He called their attention to the fact that the building in which the convention was being held was a result of the courage and energy of electrical engineers in general and of Mr. John I. Beggs, president of the company, in particular.

In his address to the members, President Wheeler took for his subject "Engineering Ethics." He urged upon the members that they interest themselves in improving the moral standard of the profession and in strengthening their sense of the obligation that binds all engineers to a course that is honourable.

"The habit of calling us 'professional,'" he said, "though not strictly accurate, does not harm, and by encouraging us to greater care and conscientiousness, ought to benefit. My wish is to draw the attention of engineers and others who are engaged for the people in handling the forces of nature and in interpreting its laws to the propriety and necessity of regarding themselves as in the same category with the strictly professional man. The attitude of the public contributes to this obligation. The duty of the engineer is as great as that of the physician to his patient, although engineers do not generally recognize such responsibility. On the other hand, the public finds no such declarations of high standards in the engineering profession as in the older professions.

"The usual duties of the engineer may be summarized as follows:—To see that the client's interests are protected; that he is wisely educated or advised as to what he ought to have, and that he gets this information; to see that the public is not imposed upon by misinformation. He should so conduct himself as to stand well in his society, the members of which are his peers, and are, therefore, the men whose commendation the world will accept."

In conclusion, he read extracts from the proceedings of conventions of ministers, lawyers, and physicians at which certain codes of professional ethics were either adopted or discussed. Architects and civil, mechanical, and mining engineers likewise had codes, and he argued it was no more than proper that certain amenities should exist between electrical engineers and the public in general and the client in particular.

After his address, President Wheeler presented Dr. Samuel Sheldon, the newly-elected president of the Institute, who briefly expressed his appreciation of the honour conferred upon him.

The first paper, describing a repulsion induction motor, was abstracted by Dr. Steinmetz, in the absence of the author, Maurice Milch. The machine dealt with starts as a repulsion motor and runs as a single-phase induction motor. It has a large starting torque, and also a large slip at full load. Its field of application is essentially machine tool or elevator operation and similar work.

The large slip of the motor at full load, according to G. Percy Cole, would be a disadvantage in some cases. In other designs of the same type the slip was from 2½ to 3 per cent., while in the present case it was 15 per cent. Again, although the starting torque is large, the starting current is also large.

Dr. Steinmetz said that the repulsion induction motor was the only one that would give four times the full-load torque with four times normal current at starting. If, however, the motor were not to be used on rapidly fluctuating loads, the same result could be obtained with a series motor or an induction motor controlled by hand.

The next paper, comparing two and three-phase motors, was read by the author, Bradley McCormick. He reached the conclusion that the three-phase motor was superior on all points to the two-phase type.

Dr. Steinmetz spoke of tests made on a machine connected for twelve six-phases, three or two phases, the exciting volt-amperes being the same for all. With single-phase connections, however, the exciting volt-amperes were somewhat lower, the maximum output being 35 to 40 per cent. of that with polyphase connections.

MONDAY AFTERNOON

At the afternoon session the third paper, on "Heat Tests on Alternators," was read by the author, Sebastian Senstius. He described a series of methods developed by him as substitutes for full-load heat tests, all based on the assumption that the short-circuit test gives the data to predetermine in a sufficiently accurate way the regulation of an alternator, and also its normal field current and flux. Current is brought into the armature winding at such points that no induced e. m. f. has to be overcome.

In the opinion of Dr. Steinmetz, methods of making heat tests on alternators were becoming of such importance as to warrant being considered by the committee on standardization. For large machines, tests could not be made under conditions of operation, as too much power was required, hence the importance of such tests as those described.

In discussing "Direct-Current Motor Design, as Influenced by the interpole," C. H. Bedell told of the advantages of the interpole in preserving the field of commutation in direct-current motors.

Experience with the auxiliary poles applied to machines of from ½ H. P. to 2000 KW., according to H. F. T. Erben, had shown that it was a valuable feature. Good regulation may be obtained with the brushes of an interpole motor in the neutral position. By shifting the brushes, 10 per cent. overcompounding may be had with sparkless commutation.

In speaking of an interpole motor for railway work, Mr. Bedell told of an instance in which a 10-H. P. motor was run with 100 per cent. overload and 9 per cent. field excitation without sparking.

President Wheeler advocated the

multiple-voltage system for variable-speed work, as giving a simpler motor.

TUESDAY MORNING

On Tuesday morning the meeting place was changed to one of the assembly rooms of the University building, as the auditorium had proved too large. The morning was devoted to the reading and discussion of papers on protection from lightning and the report of the committee on standardization.

Farley Osgood described the experiences of the New Milford Power Company, of New Milford, Conn., with multi-gap series resistance arresters, and also those without the resistance, during the years 1904 and 1905, on a 33,000-volt transmission system. The paper by E. E. F. Creighton on "Methods of Testing Protective Apparatus," described a number of laboratory tests made by the author and intended, as far as possible, to be under working conditions. H. C. Wirt discussed "Protective Apparatus for Lightning and Static Strains," the type of arresters chiefly dealt with being multi-gap with non-arcing metals.

In opening the discussion, Dr. Steinmetz said that a standard must be set for lightning arresters, so that we may know what to expect of them. It must not be expected that arresters at the central station and the sub-stations will protect the whole system. In this case, all that can be done is to protect the apparatus as well as possible from the overflow of static disturbances or voltage from the line.

In selecting a route for the transmission line, the question of lightning is an important factor. The pole line must be located so as to keep it as free as possible from lightning effects. Isolated hills and west slopes near the summit should be avoided.

As a special protection, Dr. Steinmetz advocated a grounded overhead conductor, placed high enough above the transmission line to be effective. It should have high current-carrying capacity, and should be grounded often. He suggested a steel cable, running from one pole top to another, serving also as a mechanical support to the line. Three grounded conductors, one each side of the line, should be used in very exposed places in addition to the overhead conductor.

Regarding the series resistance in the low-equivalent type of arrester, Percy H. Thomas said that it need not be high, but it was not desirable to omit it entirely. Its function was to limit the dynamic current and to aid in extinguishing the arc. The number of gaps in series required to break the arc will depend on the inductance of the circuit. He criticised Prof. Creighton's tests using very high frequencies.

In reply, Prof. Creighton said that after a lightning stroke currents may oscillate at frequencies of several hundred kilo-cycles in sections of the line, and it should be possible for an arrester to remove these surges.

The mere fact that arresters connected from line to line may discharge in series, said J. B. Taylor, was not proof that a high potential existed between the wires; it may rather be due to the gaps acting as condensers at a very high frequency oscillation.

In the opinion of N. J. Neall, the various types of arresters should be tested under exactly similar conditions in order that comparisons might be made of their relative effectiveness. Laboratory tests are of no use for high-voltage conditions.

P. M. Lincoln said that the three problems to be solved in designing arresters were to keep high-frequency surges out of the power house, to provide a path for their escape, and to prevent the dynamo current from following the arc. The third problem is the most difficult one, and has not yet been solved successfully.

The overhead grounded line, said Dr. F. A. C. Perrine, is of great importance, as it lessens the amount of work which the arresters have to perform.

The proposed standardization rules were also discussed at this session. In the opinion of some, the requirements were too severe and placed unnecessary limitations on the manufacturer, notably as to rheostats, lightning arresters, lighting units, lamp testing, and direct-connected generators. It was finally decided to refer the rules back to the committee, so that members and others interested might receive copies for comment. The committee were authorized to make the necessary changes and submit the rules to the board of directors for publication.

At 2.30 o'clock the members boarded special cars of the Milwaukee Electric Railway & Light Company and proceeded to West Allis, of the Allis-Chalmers Company, where they were the guests of President W. H. Whiteside and his associates, of the well-known Milwaukee company. Each department was inspected and the methods and the character of work in each pointed out to the visitors. A luncheon was also served the members at the works and a group photograph was taken. For the ladies, an automobile ride and luncheon at the Milwaukee Country Club was provided.

Wednesday being Decoration Day, it was thought that the visits to the various plants would better be postponed till Thursday, and so the papers scheduled for that day were read at the afternoon session.

The first paper of the morning, by W. L. Waters, on "Shunt and Compound-wound Converters for Railway Work," discussed the relative advantages of both types, concluding that the shunt-wound converter was the more desirable.

J. B. Taylor disagreed with the author, and said that the use of compound-wound converters, especially in small stations or where the load is not uniform, would be the practice for many years to come. The compound winding compensates automatically for line drop, and all that is necessary to divide the load properly is to adjust the shunt of the series field. The series winding fixes the polarity at starting. The efficiency of compound-wound machines also is high.

P. M. Lincoln said that the characteristic of a shunt-wound converter was the same as that of a shunt-wound generator, although it drooped somewhat less. For railway work a rising characteristic was necessary; hence the compound winding must be used. The added cost of the compound winding was not appreciable, though a slight cost was added to that of switching apparatus. By obtaining the necessary reactance from the transformers, the cost of reactance coils is saved.

In reply, Mr. Waters said that 50 per cent. more copper was required in the fields for compound winding in order to control the power factor; hence a compound-wound converter would cost much more than a shunt-wound machine. Special transformers must be used if the necessary reactance is to be obtained from them.

In his paper on "The Self-Synchronizing of Alternators," Prof Morgan Brooks described a method of throwing synchronous frequency converters in parallel. There was no discussion on this paper.

In the next paper, Prof. C. F. Burgess dealt with the magnetic properties of electrolytic iron. Hysteresis tests were made of the iron before and after heating for eight hours at 1200 degrees Cent., the iron being imbedded in magnesium oxide. After heating, the iron exhibited very low hysteresis losses.

E. F. Northrup thought that a D'Arsonval galvanometer could be used if it were provided with a narrow coil heavily weighted. A series resistance of manganin should also be used, as it had a low temperature coefficient.

Prof. D. C. Jackson said that one of the problems met with in dealing with electrolytic iron was to keep it pure when melted.

Dr. Steinmetz said that he had found an alloy of copper, manganese and aluminum to have a high magnetic permeability, and to be capable of being permanently magnetized. These properties are exhibited when the alloy is heated and then cooled. He discussed other magnetic alloys, and concluded by saying that it might be possible to find an alloy having a higher magnetic permeability than iron.

The next paper, by E. F. Northrup, on "Measurement of Temperature by Electrical Means," dealt with the design and construction of resistance thermometers and the methods for measuring their resistances. In reply to a question as to their use for measuring steam temperatures, the author said that instruments using a wire spiral had been designed and were in use.

On a motion by Dr. Steinmetz, the president and the board of directors were authorized to formulate a tentative code of ethics for electrical engineers, to be submitted to the members of the Institute for comment.

The paper on the "Educational Value of an Electric Test Car," by Prof. T. M. Gardiner, was read by M. K. Akers. The paper described the new electrical test car now being equipped by the University of Illinois, and gave an outline of the tests to be made.

"The Art of Inventing," by E. J. Prindle, was the title of the next paper. The author described a logical method of working out an invention from a given problem. In discussing the paper, Dr. Steinmetz said that inventing was the regular work of the engineer. He gathers data, takes what he wants and puts it together. He believed the professional inventor to be only one step above the professional promoter.

The question of local organizations was brought up by Charles F. Scott, chairman of the committee on local organizations. There had been some feeling, he said, against New York, but the headquarters must remain there. There must, however, be co-operation with the local organizations, which should be as parts of the whole.

Dr. Steinmetz suggested that the local organizations be represented at the meetings of the board of directors, though the representatives would have no vote. Dr. Sheldon said that while many opinions existed as to what constituted the success of the Institute, yet all the members had its welfare at heart. He believed that the list of full members should be increased by transfers from the eligible list of associate members. He suggested that the branches cooperate with the committee on papers in securing desirable papers for the meetings.

The afternoon session of Wednesday opened with a paper by D. C. Jackson on "Economies Derivable from the Use of Relatively Small Water-powers of Low Head in the Middle West." The author described the plants of the Janesville Electric Company in Wisconsin, which utilize three separate water-powers, two for continuous service and one for peak-load service. The paper was not discussed.

In his paper on "Some Fundamental Characteristics of Mercury Vapour Apparatus," Percy H. Thomas dealt with the more prominent fundamental characteristics of mercury vapour lamps and converters, and gave his conception of the nature of the phenomena consistent with the latest theory of electricity.

Dr. Steinmetz believed that the phenomena exhibited in mercury vapour apparatus was not different from that in any arc. He did not believe in the ionization theory. Connecting converters in series he thought unnecessary, as he had obtained 6000 volts from one tube, and even 25,000 volts without short-circuiting. Tubes supplying current at 4000 to 7000 volts are now in use on arc-lighting circuits.

The paper on "Safety Devices for Steam Engines, Turbines and Motors," by C. M. Heminway, was read by title. W. L. R. Emmet described the centrifugal speed-limiting device used on Curtis turbines to control the admission of steam.

The concluding paper of the session, "Some Notes on the Lighting of Churches," by E. R. Weeks, was read by A. S. McAllister. As there was no discussion on the paper, the convention adjourned.

The members were then taken by special cars and by boat to Whitefish Bay, where a whitefish dinner was served at six o'clock. Thursday was set apart for visits of inspection to various plants in the city, the following being included in the list:—The Wisconsin Telephone Company's new grand exchange and main office building; the Commerce Street power house of the Milwaukee Electric Railway & Light Company; the Semet-Solvay Company; the Cutler Hammer Manufacturing Company; the National Brake & Electric Company; Pawling & Harnischfeger; the Johnson Service Company; the Nordberg Manufacturing Company, and the Fred. M. Prescott Steam Pump Company.

A banquet had been arranged for Thursday evening, but as a large number of the members and guests had arranged to leave the city on that day, the plan was abandoned.

A Hot-Wire Ammeter

IN a recent number of "The Electrical Journal," E. C. Wheeler tells how current was approximately measured by means of a hot copper wire.

The equipment of a large power plant was recently installed in which the installation of the generators was in charge of one company and the installation of a bench type of switchboard for the control of the plant was in charge of another company. The contract for the control apparatus stated that the use of the finished board or temporary apparatus was to be furnished for any tests that the purchasers might desire to make.

The company supplying the generators was ready to dry out their machines, and notification was given to that effect. There were no ammeters on hand and none to be had at that time.

Some tests had been made by the writer a short time before to determine how much current was necessary to fuse copper wire, and some notes had been kept of the amount of current necessary to heat copper wire of various sizes to a red heat. The idea occurred to utilize this data as a means of determining the amount of current in the generator when running on a short-circuit heat run.

A few experiments, during which a thermometer was kept in the windings of the armature, showed this to be a thoroughly practical method, as the current was to be kept constant. The switchboard operator simply had to look at the hot wire to note the current approximately. This arrangement was so satisfactory to the engineers present that they expressed the purpose of following the example if ever caught in a similar situation.

About 1500 power stations are in operation in Germany with a total capacity of about 350,000 H. P.

The National Electric Light Association

Annual Convention at Atlantic City, June 5 to 8

ARTHUR WILLIAMS, THE NEW PRESIDENT OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

BY far the most successful of the conventions of the National Electric Light Association was that held this month at Atlantic City. The importance of the subjects discussed in the papers read, the features provided for the entertainment of the guests, the excellent exhibits of the associate members, and the large number present, all contributed toward the success of the meeting. Up to Thursday nearly 1500 members and guests had registered at the secretary's office.

The exhibits in the main hall were notable as being more extensive than those of preceding conventions. The exhibits of central station advertising literature were also worthy of attention. Cover plates of monthly bulletins, pamphlets, circulars, and folders of several of the companies operating in the larger cities were shown in large variety.

The convention was called to order by President William H. Blood, Jr., shortly after 10 o'clock on Tuesday morning, June 5. After a brief address of welcome by the Hon. F. P. Story, Mayor of Atlantic City, President Blood addressed the convention.

He congratulated the association on its growth. Two years ago the membership was 558. To-day it is 1024. The question of annual dues should have prompt consideration. It may be expedient to increase the fees of companies operating in large cities. It is desirable to adjust the dues so that companies in cities of 10,000 population or under cannot afford to stay out of the association.

He recommended that class "C" members, — college professors, — be treated as an honorary class, that no fees be exacted, and that they be admitted on invitation only.

The year has shown a healthy increase in the electric lighting business. There has been a marked increase in centralizing the ownership of electrical undertakings.

Allied with the question of rates is the problem of government supervision or regulation. Municipal ownership is no longer as popular as it once was. Some agitation, however, is being kept up by the socialist, the political agitator, and the "yellow journal."

A general reduction in price for current and a readjustment of rates are constantly taking place all over the country. Flat rates are fast becoming things of the past, and wattmeters, in conjunction with various kinds of demand systems, are now almost universally used. The public still objects to the demand system of charging, and we may have to return to the straight meter rate, which though admittedly unjust, has a decided advantage in its simplicity.

In reading the report of the committee on progress, T. C. Martin said that the chief item of statistical interest was that showing an increase of about 600 new central stations during the past year. This would bring the investment up to $700,000,000, a figure hardly equalled in any other public service development in this or other countries. The gross earnings on this investment were $135,000,000 and the expenses $95,000,000. The report also stated that the production of electrical apparatus in the United States in 1904, the latest figures available, was $157,000,000, nearly $100,000,000 of which were used in the central station branch of the electrical industry.

The first paper taken up was that by W. S. Barstow on "Mercury Arc Rectifier System with Magnetite Lamps for Street Illumination." This paper is given in full elsewhere in this issue.

In answer to a question by J. H. Hallberg, Mr. Barstow said that the minimum cost of the tube is $15 for a 75-light set, and this about balances the labour of attendance and renewals on the motor-generator set. The labour cost is very small on the mercury-arc rectifier system, one attendant taking care of a 1200-light installation and also all the other station apparatus.

P. D. Wagoner said that the cost given by Mr. Barstow was a figure arrived at when the industry was very young and little data as to manufacture was obtainable. A more accurate figure would be $25, with a $5 rebate for the return of the old tube. The important consideration, however, is the maintenance per circuit per year from the tube standpoint. Ordinary tube life is 400 hours, which, on an average circuit, would be ten tubes per year, at a net price of $20, $200 per circuit per year, which even on a 50-light circuit would be only $4 per lamp per year. The other economies mentioned are so great that the cost of tube renewals is an insignificant quantity.

DUDLEY FARRAND, THE NEW FIRST VICE-PRESIDENT

In reply to a question by Arthur Williams as to the performance of the lamps, Mr. Barstow said that at the beginning the outages were frequent, the main trouble being with the magnetite sticks. These were packed by hand and the inequalities in the work produced a slag which caused the outage. When sticks packed by automatic machines were used, this trouble ended. In the past year trouble in starting up the lamp

W. C. L. EGLIN, SECRETARY OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

was experienced, owing to the fact that the metallic magnetite electrode required considerable time to heat to form the arc. This was overcome by arranging for the transformer to give an increased voltage at the start, running up the current to 4.5 amperes at the start.

Dudley Farrand asked how the lamps were rated in the Portland contract. Say the lamp takes 320 watts, what is the specification of candle-power consumption? In reply, Mr. Barstow said that the problem was a serious one. The way it was solved was to show the lamps burning side by side, showing the superiority of the magnetite lamp over the other, and then get a release from the city engineer waiving that part of the agreement calling for "watts in the arc" and placing it on the basis of equal or satisfactory illumination.

In answer to C. A. S. Howlett's question as to the relative efficiency of alternating-current and direct-current operation, Mr. Barstow said that it was 4 per cent. in favour of the alternating-current machine with the tub transformer. The efficiency is about 82 per cent. in one case and 78 per cent. in the other.

The next paper read was by L. B. Marks on "The Flaming Carbon Arc Lamp." This paper is given elsewhere in this issue.

P. D. Wagoner said that it would be of interest to note that with the luminous magnetite lamp the cost of carbon or electrodes would be 1-40 that of the carbons of the flaming arc lamp, taking the latter as 15 cents.

Samuel Scovil asked what the probability was of the cost of the carbons being materially reduced. In reply, Mr. Marks said that with a carbon such as the Blondel carbon, we cannot look for any great reduction below the present price in Europe, say 6 or 7 cents. The difficulty is in securing homogeneity in the carbon. The foreign substance which gives the light must be placed in the carbon in exactly the right way; it must be built up.

The lamp would undoubtedly have an application for lighthouse use, as its fog-penetrating power was wonderful.

L. J. Auerbacher said that the flaming arc would light up a store front more economically and better than any other form of artificial illumination. The cost of carbons, 7 to 10 cents a pair, and the cost of trimming are assumed by the customer. The cost of carbons will be gradually reduced; whereas a few months ago they were costing the consumer 15 cents a pair, carbons burning the same number of hours can now be bought for 10 cents.

TUESDAY AFTERNOON

The session on Tuesday afternoon opened with the reading, by W. C. L. Eglin, of the report of the committee on steam turbines. This report dealt with the recent improvements made in the Curtis, Westinghouse-Parsons, and Allis-Chalmers-Parsons steam turbines. A supplementary report was added by I. E. Moultrop on steam turbines abroad.

The paper on "Mechanical Refrigeration," by John Meyer, first described the various systems of refrigeration and then discussed the various uses to which motor-driven apparatus might be put, to build up the central station load.

L. H. Scherck asked what inducements in securing business it had been necessary to offer in the way of guarantees, either by local companies or by the refrigerating companies, in order to have especially small consumers go to the necessary expense of installing these plants. Mr. Meyer said that his company, the Philadelphia Electric Company, had only furnished current for one or two months. He did not know what arrangements were made by the refrigerating company.

W. W. Freeman said the difficulty in Brooklyn had been that orders for the apparatus could not be filled in any reasonable length of time. F. E. Matthews said that this was due to the abnormal conditions, that manufacturers were unable to make deliveries short of ninety days and some more than that. The extent of the field for the small machines had not been realized by the manufacturers. They will, however, undoubtedly adopt measures to meet these abnormal conditions.

S. B. Storer asked if any attempt had been made to use ice machines for supplying a low spot in the load curve. Mr. Meyer said that his company treated the refrigerating problem the same as the general power proposition. It is a mistaken idea that the refrigerating business does not cost you as much as the general power business. The paper showed that in a restaurant the machine ran from 12 M. to 9 P. M. all the year.

D. F. McGee said that in Red Oak, Ia., no difficulty had been met in making contracts with butcher shops and wholesale and retail grocers with stationary ice-boxes. No difficulty was encountered in making contracts to keep off the peak load when a storage tank was installed in connection with the machines. A

CHAS. R. HUNTLEY, NEWLY-ELECTED MEMBER OF THE EXECUTIVE COMMITTEE

low rate had been made and had proved satisfactory.

The paper on "Fuel Economy," by J. H. Hallberg, described an automatic CO_2 recorder. This apparatus was described in the April number of THE ELECTRICAL AGE.

In answer to a question, Mr. Hallberg said that it was $375 f. o. b. docks, New York. L. R. Nash was of the opinion that hand-operated devices would give very satisfactory results. He had decided that he would experiment with a hand-operated device and determine whether the possible additional economy obtained by having a continuous record would justify the extra expense of the continuous recorder.

Mr. Hallberg said that the use of hand-operated instruments should be avoided. It was of vital importance to know at all times what was going on in the furnace. One plant in New York City had saved more than $300 per day by the use of a continuous recorder.

"Electric Heating and the Residence Customer" was the title of the next paper, by James I. Ayer. The author discussed ways and means for educating the public in the use of electric heating devices.

In discussing the paper, Max Loewenthal said that the "fad and fancy" period in electric heating had been passed. While very little that is new could be presented in the matter of new appliances and applications, a great deal of added interest is being taken in the wants of customers. In spite of this, the development of electric heating has been small, and is still very limited. We will not be satisfied until we can have a house wired for current instead of piped for gas.

In only 44 per cent. of the 5000 cities in the United States is current available, and in these cities only a small part of the population use it. This is because the public is not educated in its use, and because it is prejudiced against all things electrical. The main reason for the limited development, however, is the short-sightedness of the central station man, believing, as he does, that his work is only to generate and transmit current. He must become a merchant and employ the tools of a salesman. The operation of the appliances should be demonstrated. To become thoroughly familiar with them, the central station man should install them in his own home. Absolute confidence must be had in electric heating, not only in its future development, but also in the efficiency of the apparatus and the fact that the public wants them.

Figures gathered by Mr. Loewenthal showed that for a period of two years all the ironing and cooking for a family of three or four could be done for about $6 or $7 a month at a 5-cent rate. He suggested that central station men co-operate with architects and builders, as in several cases it had been found that by putting in only a furnace with a small space for coal storage, thus requiring but little excavating, and by leaving out the coal range and the gas stove, and, of course, installing no gas pipes, the saving effected would amply pay for electric heating circuits and for the entire electric kitchen equipment.

E. F. McCabe said that he had found the trouble not to be the short-sightedness of the central station man, but rather the slowness of the apparatus itself. H. L. Wallau said that in Cleveland they had to contend with natural gas at 30 cents per 1000 cubic feet. The cost by electricity per month for a small family would be $4. With natural gas, cooking and heating water for bathing and washing clothes would cost 90 cents a month; with manufactured gas at 75 cents, it would cost $2.50 a month.

Mr. Ayer said that the last two speakers emphasized his argument. Cleveland is a very satisfactory market. He wanted to impress on them not to go after big things, electric cooking, selling electric ranges against gas ranges until they knew all about it themselves. It will not be a question of argument, but of observation. Provide articles of use and comfort about the houses which are supplied for lighting service only. While these smaller things are being pushed knowledge can be obtained of what the cooking process is.

The paper on "Line Construction for Overhead Light and Power Service," by Paul Spencer, was read by W. D. Partridge. The points to be considered in line construction were the safety of the public and the company's employees, the reliability of the service, and the sightliness of construction.

E. F. McCabe asked if a perfectly satisfactory strain insulator for 6600 volts for guide wires in alternating-current circuits had been found. Mr. Partridge said that the best protection for the guide wire was never to bring it within 8 or 10 feet of the ground. Asked as to whether it would be desirable to install large transformers on poles carrying two or three telegraph lines, the speaker said that he would put them there if he had room.

In speaking of cross-arms, W. T. Morrison said that he had been unable to obtain bids on all-heartwood. E. F. McCabe had found that a creosoted arm would go as quickly as one not treated. He had found that white pine lasted as long as yellow pine, and in some cases longer.

In regard to ground wires, W. F. Wells asked how a permanent ground could be had where poles are set in sandy soil. J. T. Hutchinson said that in Rochester the street railway track was used for a ground, and where this could not be had, a ground was made to water pipes.

WEDNESDAY MORNING

The first paper at the Wednesday morning session was on "Business-Getting Methods," by F. W. Frueaff. After the paper had been read by John Craig Hammond, President Blood announced that to judge the papers on "Organization and Conduct of a New-Business Development for Central Stations in Cities of Under 50,000 Population," for which $1000 in prizes were to be awarded by the Co-operative Electrical Development Association, he had appointed Douglas Burnett, E. H. Mathers and J. E. Montague. Twenty papers had been sent in, and the winners were to be announced at the Thursday morning session.

D. F. McGee then read his paper on "How to Make a Small Electric Light Plant Pay," and "Methods Used in Securing and Retaining Business" was discussed in short papers by M. E. Turner, N. T. Wilcox, G. N. Tidd, R. S. Wallace, G. B. Tripp, and L. H. Scherck. In the absence of Messrs. Wilcox and Tripp, their papers were read by Mr. F. N. Sanderson and Mr. Wallau, respectively.

In opening the discussion, President Blood said that Mr. Scherck had emphasized one point which is coming more and more to the front, that of going after the large customer and giving him a low rate. M. S. Seelman believed that the best results are to be obtained by the advertising of a specific proposition after the way has been paved by general advertising. Good results had been obtained by sending out return post cards with circulars. In order to retain business, he believed that each monthly bill should be compared with the bill for the same month in the previous year, and if there is any marked dropping off, the case should be called to the attention of the sales department of the company.

J. F. Gilchrist said he inferred from Mr. Frueaff's paper that only good business should be sought and that poor business should be avoided. He believed that they should go after all the business they could get. Differential rates will, in a measure, take care of the difference in customers. It must not be forgotten that the customer with poor business is one of the factors in public opinion in the community.

In Chicago, the solicitors were given certain territories, in which they were expected to obtain a certain amount of business each year. Above that a small commission is paid on each 15 candle-power equivalent, and a larger commission per customer, 1 cent for a 16-candle-power lamp, and in addition 50 cents a customer.

W. H. Gardner thought that unprofitable customers should be sought only if they could be made profitable within a reasonable time. J. S. Codman believed it of great importance that the rates of any company be thoroughly well known and published. W. Freeman said that the theoretical way to settle the question of rates was to charge each customer in proportion to the cost to the company. In practice this cannot be done, and many customers must be supplied at a loss. He believed the plan of paying commissions monthly the correct one.

C. H. Herrick moved that a committee of five be appointed by the president to investigate, collect, and suggest methods for the sale of electricity, to report at the next annual convention, and to be known as the "Committee on Exploitation."

The paper on "Free Electric Signs," by J. F. Gilchrist, was read by J. M. Gilchrist. The paper dealt with the "free" electric sign as a factor in central station prosperity, and discussed the electric sign conditions in the United States.

Percy Ingalls asked whether, in the patrol system spoken of, the patrolman turned the signs on as well as off. The practice in Chicago, Mr. Gilchrist said, in the congested part of the city where there are many customers in a small area, was to cover it by patrolmen to switch the lamp on and off. A man in the central section of the city could tend 100 signs with ease; their pay was about $60 a month. In outer districts the signs were placed on a meter basis, the consumer guaranteeing a certain consumption monthly and switching his own sign.

Mr. Ingalls said that in New Jersey about 636 free signs were on a meter basis, at regular rates, with a minimum varying from $5 to $15 a month, according to the size of the sign. From 600 signs the revenue was about $60,000 a year. With a minimum charge per month, whether current is used or not, a much higher rate is obtained than is supposed to be charged.

E. W. Lloyd said that in Chicago the revenue from sign lighting was about $300,000 a year, with more than 3000 signs in use.

WEDNESDAY AFTERNOON

"Profitable Commercial Co-operation," by J. Robert Crouse, was the first paper read at the Wednesday afternoon session.

After the reading of the paper, J. F. Gilchrist read the report of the committee to co-operate with manufacturers on advertising. It was moved to adopt the recommendation in the report that the committee be continued for another year. J. F. Gilchrist said he believed that the best results from the proposed co-operation would reach the central stations. There was undoubtedly an inclination on the part of central station men to shrug their shoulders and say it was a scheme of the manufacturers to sell their goods. It was, but it was a good, clean one.

The report of the committee on protection from lightning during 1905 was then read by R. S. Stewart.

N. J. Neal opened the discussion by saying that the matter should be carried on for three or four years. A good plan would be to have plants selected which were known for their vulnerability to discharges, and have them carefully watched. He thought the number of companies which had reported were but a small percentage of all. Points which he thought the report should cover were the number of lightning storms per system, the percentage of total arresters lost by failure, and the arresters per point of power delivered, that is, on a transmission line with a power house and sub-station, the importance of the protective apparatus is much greater than on a line distributing power over large territory with about a thousand transformers. Perhaps each transformer is not properly protected. He thought the report misleading in this respect.

Resistances, said Mr. Neal, at present have a certain defect, and they are a compromise of the best resistances suitable for the purpose. A trough of salt water has a very free discharge but a very low resistance, and it is too bulky. If the wire is doubled back on itself, the static field will be reduced so that the freedom of discharge is much improved. The carbon pencil is a good, compact form, but has a small current-carrying capacity and a high equivalent spark gap under certain conditions. Even with this it is one of the best forms to meet the conditions for which it is intended. Wire immersed in oil is another form of resistance used abroad. Still another form is wet earth covered with oil to retain the moisture. Of the devices now on the market it is safe to say that, so far as their form goes, they have accomplished about all that could be asked. Another matter omitted in the report is the methods of grounding. The quality of ground and general conditions have a great deal to do with the performance of protective apparatus.

H. C. Wirt thought the report showed that the arresters operated about equally well, and it was difficult to see how they could be improved. The data regarding choke coils is half in favour of their use and half against it. The paper mentioned that very rarely any static trouble was had, that is, trouble due to normal operating conditions. He knew of one case in which a current transformer grounded and about 4500 KW. was shot into the system. If companies all reported their troubles, they would be found to be serious. He knew of one or two systems where these troubles were nearly continuous, 30 or 40 in a very short period. Most manufacturers admit that they cannot wholly protect the system from this trouble. Much data had been recently published regarding these troubles, and he believed the problem would be solved.

The paper, by Sidney Hosmer, on "Grounding Secondary Alternating-Current Systems," was read by C. H. Herrick.

P. H. Bartlett said that considerable preliminary work had been done in this direction in Philadelphia. He asked if any difficulty was had in obtaining the concession to 10,000 volts from the insurance interests, and also what percentage of the installations did not come up to these modified requirements.

W. T. Morrison said that in New York grounds were obtained by the plate method largely, and also by a bunch of copper wires, the wire extending down the pole line. Tests made by him in a large system showed that the grounds made in the usual manner were very poor. After mapping out a system with the secondary loop-hole wires, and estimating the cost of extending the neutral throughout the system, grounded heavily at the station to a large water main, it was found that the cost would be less than that given in the paper. This was, perhaps, partly due to a large number of customers being on secondary mains, the neutrals being well extended over the pole line. The advantage of this system is that it keeps any accident on the pole line.

On another system, to make a ground, a copper plate about 3 feet long and 2 feet wide was buried near the river, according to the rule, putting down a barrel of coke, then the plate, and then another barrel of coke It was found that there were 30 or 40 volts between the plate and the ground, showing what poor results are obtained in grounding the plates. In very large districts where there are many secondary mains, it is advisable to extend the neutral and ground each transformer on the water main.

The report of the committee on the fire hazard of electricity was read by H. C. Wirt.

W. H. Merrill, Jr., was greatly interested in the allusion, in the president's opening address, to the employment by the association of an expert to look up the subject of the fire hazard. He would prove extremely valuable in finding out completely the extent to which current is permitted through carelessness, ignorance and lack of common safeguards to go beyond bounds and destroy life and property.

C. J. H. Woodbury cited, as an example of how safely electricity can be applied for illumination, the case of the factory mill insurance companies, engaged largely in insurance of cotton mills. During the period of fourteen years there was not a known fire in all the $100,000,000 worth of property which was ascribed to electric lighting.

THURSDAY MORNING

The session Thursday morning opened with a paper on "Alternating-Current Systems of Distribution and Their Automatic Regulation," by Charles W. Stone. The author discussed the following systems of distribution:—Single-phase, two-phase three-wire, two-phase four-wire, three-phase four-wire, and three-phase three-wire.

H. L. Wallau said they were operating in Cleveland on a 11,000-volt wide-connection transmission system, with grounded neutral both at the main station and at all substations, and he asked if any trouble would be had with stray currents due to railway circuits. Three-phase, three-wire primary circuits were used, with some single-phase distributing mains running down short cross-streets. In one very congested district a load of 400 KW. was distributed underground by a three-phase, four-wire secondary system. The balance on this finally became so bad that the system was discarded except where it cannot readily be changed.

In reply, Mr. Stone said that he did not think the three-phase grounded neutral would cause much trouble, as the principal difficulty was due to a great number of grounds made very close to the railway circuits. He thought that the single-phase system was better, or at least as good, as the three-phase, three-wire, and although a little more copper must be used, considerable complication can be saved in the main station.

One thing brought out in the paper was that with any automatic regulator operating directly on the generator, it is possible to take care of the differences in the peaks on the feeders, but he had suggested taking some one important feeder, or perhaps one of a number of them, and regulating for that feeder, and this will come very near what the others require. If this is impossible, compounding can be dispensed with and the regulator used only to maintain constant potential.

J. F. Geises asked if the regulators described were in general use at present, and whether they required much attention. Replying, Mr. Stone said that a large number were in use in Chicago and in Toledo, and require very little attention and small maintenance.

"The Maintenance and Calibration of Service Meters," by William Bradshaw, was the next paper read.

In opening the discussion, J. F. Becker said that the system outlined had been in successful use by the Brooklyn Edison Company for the past three years. He asked if the Mowbray test meter could be applied in testing polyphase meters on a three-phase, 25-cycle system, the power factor being between 10 and 50 per cent.

Mr. Bradshaw said he saw no reason why the meter could not be used. He thought the calibration of the meter best made by using it as a single-phase meter, and if it is properly lagged and arranged for zero power factor, it should be accurate on inductive load. He thought better results might be obtained if instead of taking only one field at a time, as Mr. Becker had done, both fields be calibrated together.

Edward Weston said that errors in instruments of the dynamometer type are due to other causes than the springs. Springs properly constructed will show an error of less than 1-10 of 1 per cent., or even 1-100 of 1 per cent. They should be tested by the application of a weight at a known distance from the centre. As to Mr. Bradshaw's statement that manganin, which is universally used in resistance coils, shows a tendency, if at all, to decrease in resistance, Mr. Weston said that the resistance sometimes increases and sometimes diminishes quite considerably. It is more apparent with thin wires than with thick ones, so that too much reliance must not be placed on manganin standards of resistance.

The next paper read, "Alternating-Current Elevators," by W. N. Dickinson, Jr., is given elsewhere in these pages.

Commenting on the statement in the paper regarding the use of mercury arc rectifiers in connection with elevators, P. D. Wagoner said that it is possible to maintain the arc during the period referred to with a loss of energy not exceeding 100 watts. He thought it possible that rectifiers might be applied without the use of a storage battery. He had seen a trolley car taking current from a rectifier, the energy required being as great as that in elevator service and the load fluctuating as much.

For about a year, said W. A. Layman, the Wagner Electric Manufacutring Company had been endeavouring to introduce a single-phase elevator motor designed by the engineer who had been doing most of the European work. Starting resistance had been used because it was felt that American central stations would require it to keep down the starting current. The same equipments can be employed without starting resistance, and the starting current kept down to reasonable limits. They had been trying to get a type of motor that would give full-load torque with practically full-load current, or half torque at half load. For this reason starting resistance was used.

He thought the greatest difficulty in the alternating-current elevator situation had been that the elevator companies had not recognized that the central station man has anything to do with the question, and his ideas have not been sought.

The reasons for the slow development of the single-phase elevator motor have been that it is a new line, and the manufacturers want to demonstrate what it will do; the elevator men also have little interest in it. As to the question of results of single-phase equipments compared to polyphase, the same principle applied as in ordinary power service. The central station engineer will determine where he wants polyphase service and where single-phase service.

Following the discussion on Mr. Dickinson's paper, the committee appointed to judge the best papers on business departments for central stations announced that the prizes were awarded as follows:—M. S.

Seelman, Jr., Brooklyn, $500; S. M. Kennedy, Los Angles, $300; J. M. Robb, Peoria, Ill., $200.

"Modern Switchboard Practice, With Particular Reference to Automatic Devices," by E. M. Hewlett, was next read.

H. L. Wallau thought that instead of using time-limit relays for feeder switches, for small distributing feeders carrying from 100 to 300 watts, an automatic switch controlled by an instantaneous relay would give as good protection.

The last paper of the afternoon was that on "Control of Motors on Electric Light and Power Circuits," by H. D. James. There was no discussion, and the meeting adjourned.

At the evening session on Thursday, Everett W. Burdett, of Boston, a member of the New England bar, who has given considerable attention to relations between public and corporation, spoke on "The Meaning and Proper Treatment of the Agitation for Municipal Ownership of Public Utilities."

Although men are better off today than they ever were before, and industrial conditions are superior to any known in history, he said the masses and the working classes are arrayed against capital, and in some instances against the social order.

Forgetting the beneficial results which have been obtained only through the accumulation of great wealth derived from corporate organizations, such as the establishment and maintenance of the almost countless hospitals, libraries, colleges, parks, museums, and special funds for the encouragement of learning, the dissatisfied citizen sees only the abuses of financial and corporate power of which he has been, or imagines himself to be, the victim.

He is largely influenced in favour of municipal ownership by seeing the great railroads give secret rebates, which have enriched their recipients and impoverished the unfavoured shipper, by witnessing enormous accumulations of cash and securities by life insurance companies which rightfully belong to policyholders and their beneficiaries, and by corporate power exacting high prices for poor service, securing enormous returns on fictitious capital, paying extravagant salaries, supporting wasteful expenditures, and securing legislation to enrich the few at the expense of the many.

Another reason for the popularity of the idea of municipal ownership in the United States is the favourable experience of British municipalities in public ownership. Many of our people are asking, "If municipal ownership has worked so well abroad, why is it not a good thing for this country?"

In answering this question, the first thing which is to be suggested is the danger which always lies in the off-hand adoption of foreign methods, laws, or practices in another country. It can seldom be done successfully. Differences in political, economic or social conditions almost always exist which render the transplanting of the laws, customs, or methods of one country into another inexpedient.

The remedy for existing conditions, according to Mr. Burdett, consists first, in the companies engaged in furnishing public services striving more to give good service at fair rates; second, in stopping, or at least mitigating, the abuses of great wealth and corporate privileges previously mentioned; and third, cultivating public sentiment. All members of a community should be bound together so that no member can ruthlessly injure another without ultimately feeling the recoil upon himself. "Live and let live" should be the motto.

An illustration of the soundness of the theory of public control is the State of Massachusetts which, for twelve years, has been trying the experiment. It has developed a most complete system of public control of gas, electric lighting, railroad, street railway, and other public-service corporations, and has just added the telephone industry to the others. While there are imperfections in the system, and while both the corporations and the public are at times dissatisfied with its application in specific cases, the system has, upon the whole, been advantageous to all concerned.

FRIDAY MORNING

The first paper, on "New Illuminants," by H. P. Clifford, dealt with metallized and metallic filament lamps, Nernst lamps, flame arc lamps, mercury vapour lamps, and the Moore vacuum tube.

After briefly reviewing his paper, Prof. Clifford said that careful consideration should be given to the question of replacing the present cheap carbon filament lamps, including the metallized filament, with some form of metallic filament, high-efficiency lamp. The data given of tests of metallic filament lamps, excepting tantalum lamps, showed that the voltages used were 19, 32 and 60, and not 110.

As a result of tests of tantalum lamps at the Electrical Testing Laboratories in New York, which he had personally conducted, the lamps were tested on 133 cycles and on 60 cycles. Of ten tantalum lamps tested on 133 cycles, five with clear and five with frosted globes, not one lamp gave a life of more than 99 hours, the average of the clear bulbs being 37 hours, and that of the frosted lamps being 46 hours. He could not yet say whether frosting increased the life of the lamp. On 60-cycle current the maximum life was 308 hours, the average for the clear bulbs being 178 and for the frosted 129.

On direct current, no clear bulb lamp ran over 489 hours, and no frosted bulb lamp over 609 hours, the average life of the lamps tested being 462 hours. He thought, therefore, that it was a doubtful expedient to replace carbon filament lamps at present with tantalum lamps. In the United States there are about four times as many lamps on alternating-current service as on direct-current service, and the alternating-current stations are about eight times those supplying direct current.

With the first cost of the lamp at 60 cents, and the life at 700 hours for a 2-watt, 20-candle-power lamp, it would be fatal to put the renewal charge on the consumer. There are many small stations which could not afford to give free renewals of the tantalum lamp at its present price.

In speaking of the vacuum tube system of lighting, D. McFarlan Moore claimed for it an efficiency of between 300 and 400 per cent. over that of the carbon filament lamp, and also that the tube has an indefinite life. The tube is placed up high so that it cannot be broken and is harmless to life and property; it feels comparatively cool to the hand, as compared to incandescent lamps, and could not set fire to anything.

Asked as to whether the tube could be run on 25 cycles, Mr. Moore said that a large hall, such as the convention hall, could be lighted on 25-cycle current with no greater discomfort, or not as great by 50 per cent., than would be had with arc lamps. In the earlier tubes the power factor was low, but it has been materially improved, and is now about the same as an induction motor or arc lamp, namely, above 75 per cent.

In the next paper, by F. W. Willcox, on "Higher Efficiency Incandescent Lamps, Their Value and Effect on Central Station Service," the advantages of the use of the metallized filament lamp were dealt with.

A. C. Dunham thought the metallized filament lamp the greatest improvement in electrical appliances in the last five years. It gives the stations as much income as they ever had, and gives the customer 25 per cent. more life. It runs to the limit of its useful life. They had been taking off the ordinary 16-candle-power lamp at 400 hours because it blackened. A 20-candle-power lamp goes down to a little below 17 candle-power in 600 hours and then goes out.

As to tantalum lamps, they cannot be used on alternating current without the loss of half the life, and cannot be used in any place where there is vibration. If the lamp is left alone it will burn 700 hours, but if it is taken off the circuit and tested every 50 hours, it will burn only 300 hours.

Prof. Clifford emphasized the fact that the metallized filament lamp could be used on both alternating and direct current. He hoped Mr. Willcox would not urge his recommendation for a small increase in the rate to the consumer. No matter how many curves one may have to show the lamp's greater efficiency, he believed that as long as human nature is what it is, the rates cannot be added to.

The paper on "The Edison System of Southern California," by R. H. Ballard, dealt with the system of the Edison Company, of Los Angeles. The next paper, on "The Design and Manufacture of Hydro-Electric Installations as a Whole," by E. F. Cassel, was abstracted by C. A. Tupper. There was no discussion on either of these papers.

The committee, consisting of Samuel Scovil, T. C. Martin, and Arthur Williams, appointed to consider the president's address, recommended in its report that a committee be appointed to consider the matter of annual dues.

The committee also recommended that a representative be immediately retained to devote part of his time to questions arising as to the best means of reducing the fire hazards of electricity. It was the opinion of the committee also that the policy, adopted for the present convention, of relieving local interests of the expenses of the annual meeting, was a wise one.

Letters were read from Norfolk, Minneapolis, and Saratoga Springs, inviting the association to hold the next convention in those places.

At the executive session held later, the committee on nominations submitted the following names:—

President, Arthur Williams, New York; first vice-president, Dudley Farrand, Newark, N. J.; second vice-president, Alex. Dow, Detroit, Mich.; secretary and treasurer, W. C. L. Eglin, Philadelphia; for members of the executive committee, to serve three years, Charles R. Huntley, Buffalo, N. Y.; H. T. Tate, Dayton, Ohio; and L. A. Ferguson, Chicago.

ENTERTAINMENT FEATURES

The features provided for the entertainment of the members and guests were thoroughly enjoyed by everyone. On Tuesday evening a reception and dance were given in the ballroom of the Marlborough-Blenheim. From the Inlet, at the northern end of the board walk, sailing parties embarked on Wednesday morning for an excursion off the shore. In the evening the Savoy Theatre was practically filled with delegates, guests, members of the Rejuvenated Sons of Jove, and other jovial spirits, who made merry at the expense of the players.

On Thursday morning a horseback ride on the beach was provided for the children, and in the afternoon the baseball enthusiasts organized four teams to try their skill on the diamond. Two of the contesting teams were captained by John F. Gilchrist and F. G. Vaughen, while the others were in charge of V. R. Lansingh and P. S. Klees. At the Country Club, also, the golfers contested for the president's cups, one being offered for the ladies and the other for the gentlemen. Friday morning automobiles were provided for the ladies for a tour about the city.

One of the 100-ton electric locomotives which the General Electric Company and the American Locomotive Company are jointly building for the electrified section of the New York Central Railroad, was on exhibition on Friday on a side track at the Pennsylvania Railroad station, and the members and guests were invited to inspect it.

The American-DeForest Wireless Telegraph Company has shipped two sets of sending and receiving apparatus to Mexico, to be used by a mining company to communicate between their mines and their headquarters,—a distance of 150 miles. The mine is in an isolated district, and at present there is no means of communication except "mule-back." This opens up a new field for wireless telegraphy, a means of communication which will, no doubt, be adopted by other mining companies whose mines are some distance from their headquarters, and where the building of telephone or telegraph lines would be expensive.

Annual Meeting of the New York Electrical Society

THE annual meeting of the New York Electrical Society for the election of officers was held in the college hall, in the Hotel Astor, on June 13. The following ticket was elected:—President, George Herbert Condict; vice-presidents, Robert T. Lozier, Walter F. Wells, P. G. Gossler; secretary, George H. Guy; treasurer, H A. Sinclair.

The report of the secretary showed that during the past season 59 members were elected; the society lost 2 of its members by death, and 32 resigned. The total membership is 662. Although the report of the treasurer showed a working deficit of $39.17 on February 1,—the end of the society's fiscal year,—the present condition of the finances promises well for a marked improvement in the budget of the coming season.

Much interest was aroused by the announcement that the officers of the society are hopeful of securing quarters in the United Engineering building, so that the many advantages of that edifice may be made available to the members of the society.

The business meeting was followed by a smoker, music being provided by the Eureka Trio. Among the speeches was a characteristic and witty recital of some of his personal experiences by Charles L. Eidlitz. An excellent collation was served, and the evening was voted a distinguished success.

The American Railway Association has a code of words used in railroading. With each word is a definition written by the association in such a way as to make employees familiar with the things they deal with in daily operation. Changes have recently been made by the train rules committee in some of the definitions. One change especially significant is that to the word "engine." Formerly an engine, according to the association's code, was "a locomotive propelled by steam." Now an engine is "a locomotive propelled by any form of energy." The change was made to include electric, gasoline, or other motors which are coming into use on American railroads.

The longest interurban line in the United States is that recently opened between Dayton and Toledo, a distance of 162 miles, which is covered in 5 hours and 51 minutes.

The Increasing Use of Electricity in Medicine and Surgery

THE extent to which many of the latest medical and surgical appliances depend upon electricity as an auxiliary to their convenient and often successful operation was one of the most striking lessons of the recent Boston convention of the American Medical Association. Aside from the direct remedial applications of electricity in the treatment of diseases, a marvellous development has taken place in the adaptation of the small motor to the mechanical side of the physician's work.

The whole trend of present practice seems to be away from all unnecessary personal labour of the manual kind. In the X-ray laboratory, for example, a machine has been produced for the sole purpose of rocking exposed plates in trays during the developing process, which is longer and more tedious in radiographic work than in ordinary photography. A motor of about 1-16 horse-power does the work, leaving the man in the laboratory free to attend to other matters.

Tiny saws for bone cutting, X-ray machines, vibrators for massage work, air pumps for ear and eye treatment, centrifuges for the precipitation of solids and bacteria in liquids, and other devices for office and laboratory use are driven more satisfactorily by small motors than in any other way. The centrifuge in particular has benefited by the motor drive, and cups of spun steel or aluminum have been designed for speeds as high as 6000 to 8000 revolutions per minute. The employment of a special switch, which turns the motor into a generator for the purpose of electrically braking large centrifuges to a standstill within a few seconds from a speed of 2000 to 3000 revolutions, is a notable improvement. Direct-connected centrifuges are now being made in large sizes, and the problems of mechanical strength and balance at high speeds seem to be exceedingly well worked out.

Taken as a whole, the small medical motors shown at the Boston exhibition appeared rugged and compact in design, were admirably responsive to speed control, rapid in acceleration and practically noiseless in operation. Flexibility and convenience are far more important than actual percentage efficiency in very small motors, many of which do not consume more energy than an ordinary 16-candle-power lamp. In some cases the motors were started by simply closing the line switch and throwing 110 volts direct current upon the windings without external resistance, —a certain triumph of design in comparison with the productions of but a few years ago.

The incandescent lamp has been applied to surgical work in so many different styles and sizes that nothing short of a catalogue could cover its field of usefulness. As an aid in diagnosis and an auxiliary in delicate operations in different parts of the body, the miniature lamp is an important accessory. No other known form of illumination could be safely introduced into the body, or rendered so readily aseptic.

Without the miniature lamp it is safe to say that the cystoscope would be a practical impossibility, and the remarkble development of this instrument within the past two or three years is due in large measure to the perfection with which small incandescents of high power can now be manufactured. In somewhat larger sizes, the incandescent lamp is now being applied to the illumination of microscopes, and in the chemical laboratory of the new Harvard Medical School, at Boston, special fixtures are installed beneath the tables, projecting light through an aperture directly through the microscopic slide without the intervention of a mirror.

Electric heaters of various designs shown at Boston illustrated gratifying progress in the application of this class of apparatus to medical work. One of the latest appliances is an asbestos-lined oven for dry sterilization, in which the resistance element is a perforated graphite plate instead of the usual wire. An electromagnetic switch, actuated by an adjustable mercurial column, cuts out one section of the graphite resistance in case the oven temperature becomes too high.

The electric heater has also recently been successfully applied to the operating table for the purpose of removing the chill of the glass surface. Air heaters, cautery wires and various types of arc lamp for light treatment were also shown, together with electromagnets for removing particles of steel from the eye.

For five years at least an X-ray outfit has been considered a necessity in most important hospitals, and the success which has been attained in the use of such apparatus has led to the development of some very attractive sets for the use of individual practitioners. A recent important improvement is found in an ammeter capable of measuring the current in wire-amperes obtained from the secondary of an induction coil. The addition of this instrument to the resources of the laboratory means that comparative and quantative experience can now be brought down to a more rational basis, with every prospect of improvement in the technique of X-ray treatment.

Previously it has been easy to measure the time of treatment, the distance of the source of the rays from the patient, and approximately the kind of rays. The new ammeter for secondary currents carries the data further, however, and also gives more or less information as to the condition of the vacuum in the X-ray tube itself. Aside from its use in examination and diagnosis, the modern X-ray outfit affords an opportunity for the practitioner who desires to employ the discharges as direct remedial agents. In connection with this, a large number of wall cabinets, flexibly arranged with induction coils, rheostats, motor-generators, etc., to convert central station supply into the quality of current needed for different patients, were shown at Boston, by way of meeting a variety of conditions.

A feature of incandescent electric lighting in shops and factories that has been greatly neglected, says "Machinery," is the provision of proper connections from the wire mains to the lamps used on the machines. The common practice has been to carry a double flexible cord from the nearest lamp socket to a portable lamp hung on some rickety fixture attached to the machine. That this practice is not only slovenly, but dangerous besides, has been frequently proven by the unfortunate experience of operators who have been badly shocked or burned by short circuits. Not only this, but the use of lamp cord in such a manner is wasteful; it lies around on the floor where the insulation is bruised and soon destroyed, and the amount of cord that may be needlessly used up in a large shop in the course of a year is a considerable item. Where proper attention is given to this feature of machine-shop equipment, the machines are wired as a building is, the wires being carried up inside the columns of the machines in insulated cables, and sockets are provided at various convenient points in which a plug, connected to a short length of flexible cord, can be inserted. The nearest socket, of course, is used to suit the convenience of the work.

Alternating-Current Elevators

By W. N. DICKINSON, JR.

A Paper Read at the Atlantic City Convention of the National Electric Light Association

ELEVATORS for any duty may in some manner be operated from alternating-current circuits, that is, double-belt elevators may be used with continuously running motors, hydraulic elevators may be supplied with pressure by motor-driven pumps, arranged to run continuously, or in some cases, intermittently, and direct-current elevators may be operated through the medium of motor generators, or from storage batteries charged by motor-generators or mercury arc rectifiers. Furthermore, the direct-current inductive control lends itself with almost equal readiness to the control of elevators receiving power from direct or alternating-current circuits.

From the general commercial standpoint the desired machine is, however, the direct-connected elevator employing an induction motor. It is, therefore, the direct-connected elevator with which this paper will mainly concern itself.

We have had alternating-current direct-connected elevators for about eight years, or probably the experimental machines date back eleven or twelve years. The early machines were equipped with multiphase motors with mechanical control and were of comparatively low duty, and this same general equipment and duty limitation applies to the majority of alternating-current elevators in operation to-day.

For multiphase circuits, motors with either squirrel-cage or definite wound rotors were used, the latter usually carrying collector rings to allow of connection to exterior resistance at starting. The starting resistance was sometimes inserted in the primary circuit of the motor, but more frequently in the secondary or rotor circuit.

The controller generally consisted of a three-pole double-throw switch, and, if the first rush of current was to be limited, a device for cutting out the starting resistance. This latter was usually a time element device employing gravity or spring pressure against a dash-pot retardation. This controller in conjunction with a mechanical brake was operated from the car by means of a hand rope, lever or wheel. The hand-rope controlled direct-connected elevator with squirrel-cage motor is an extremely simple machine, but its application is limited.

The mechanical control served very well for the low-speed commercial machine, but the call for an automatic elevator, that is, one requiring no operator, and usually equipped with push-button control for residence service, etc., demanded a magnetic control. As no satisfactory alternating-current magnet was available, direct-current controlling magnets and brake magnet were employed, and the direct current was obtained from a small motor generator or an aluminium cell rectifier; the elevator motor being retained, however, in the alternating-current form.

The mercury arc rectifier has been considered with respect to the supply of a direct current for these controlling magnets, but the current required to maintain the arc during the period in which no useful work is being done usually represents a loss which is prohibitive. It has been suggested that in hospitals and similar buildings, a few hall lights might be connected with the rectifier in order to make use of the arc-maintaining current, but as any rectifying process is only a half-way step toward the desired results with respect to direct-connected alternating-current elevator operation, action on this line will doubtless be limited.

While a satisfactory alternating-current magnet was not available, it must not be assumed that alternating-current magnets have never been employed. The writer has in mind an elevator in New York City installed in 1899, in connection with which alternating-current controlling and brake magnets were employed and have been in use ever since.

The early magnets exhibited, however, several objectionable features. They were noisy, took a large current with an open magnetic circuit, and provided an uncertain electrical contact. The advantage accruing from the employment of magnet control in connection with direct-current elevators made it clear that the perfecting of an alternating-current magnet was distinctly desirable and really essential to any marked advance in the alternating-current elevator field.

We are doubtless all familiar with the groaning sound made by the earlier elevators when starting, and the pronounced humming noise while running. These are motor features and have not been so noticeable in later machines and may be eliminated.

The maximum duty of direct-connected alternating-current elevators has always been low, owing to the comparatively large starting current required with collector-ring motors, and also to the difficulty experienced in stopping. In direct-current elevators the dynamic principle is employed to assist the mechanical friction at the brake shoes in bringing the elevator to rest, and in some cases this dynamic action exerts the greater part of the braking effort.

In the ordinary induction motor this dynamic action does not exist after the line current has been cut off, and the braking effort is, therefore, entirely the resultant of mechanical friction. This braking feature is extremely important, as an elevator must be able to come from speed to rest almost instantly, and the car should land within 1 or 2 inches of the desired level.

The speed of these elevators has found its maximum practical limitation at about 200 feet per minute. This maximum may be increased about 40 per cent. by so arranging the motor winding and the controller that the number of magnetic poles in the motor may be doubled when stopping, thus reducing the speed of the motor one-half before finally cutting off the line current and applying the mechanical brake. The employment of such a primary makes necessary, however, the use of a squirrel-cage form of rotor winding, and as this involves very large starting current it is usually prohibitive.

Professor Sever, of Columbia University, made some investigations as to duties, starting current, etc., of multiphase alternating-current elevators in operation in New York City, and incorporated the results in a paper which appears in the proceedings of the American Institute of Electrical Engineers of April, 1902.

In the United States but few single-phase direct-connected elevators have been installed. Small elevators, mainly for house service, and using an ordinary multiphase induction motor with a phase splitting arrangement for starting, have operated quietly and quite satisfactorily in so far as service giving is concerned, but the starting current has been large.

Single-phase commutator motors for direct-connected elevators have thus far been employed but little in this country, although in England considerable has been done along this line. That but little has been done here in single-phase work is no indication that but little will be done, and this single-phase situation will be treated of later.

So much for the general story concerning alternating-current elevators as they have been obtainable until recently. Before taking up the question of the machines that may now be offered by elevator manufacturers, and the possibilities,—we might say probabilities,—for the near future, it may be well to indicate briefly some of the difficulties that have stood in the path of development of the direct-connected alternating-current elevator.

In the first place, the standard that has been established for direct-connected work by the direct-current elevator is remarkably high, and for this reason a comparative basis of operation exists which did not exist during the early development of the direct-current machine. Again, the alternating-current motor has not been readily obtainable. It has been expensive, and the delays in delivery have militated against experimenting by the elevator manufacturer and have discouraged the elevator customer.

A SINGLE-PHASE REPULSION INDUCTION MOTOR BUILT BY THE STANLEY-G. L. ELECTRIC MANUFACTURING COMPANY, PITTSFIELD, MASS.

The electric energy consumption demanded by the motors in starting has been considerably in excess of that required by direct-current motors for the same duty, and the introduction of the power factor has augmented the consequent disturbance to the lines. The difficulty experienced in stopping has already been mentioned; while the lack of dynamic action when disconnected from the line, and the liability of reversal of phase relation on the lines of multiphase circuits, raised the question of safety. Furthermore, the noise made by the motors was distinctly objectionable.

Summarized and compared, the application of the alternating-current motor to the regular type of direct-current direct-connected elevator machine, limited the duty of the latter and rendered it expensive to install and to operate. It also made it noisy in operation, detracted from its safety, necessitated mechanical or rectified magnetic control, and affected the lights when placed on a lighting circuit.

On the other hand, the tendency of central stations toward alternating current made it clear that alternating-current elevators suitable for all classes of service would be called for, and that if real progress was to be made, existing conditions and known principles must be carefully analyzed and the latter applied to the former, singly and in combination, until a basis of present possibilities was established. This basis should constitute at least an advanced starting point for development.

Applying, in so far as possible, the experience gained in direct-current practice, it followed that the first requirement was a quietly-running motor having a large starting torque per volt-ampere of input, a reasonably small rotor weight, and good efficiency and power factor through a range of load. It further appeared that a motor having direct-current shunt motor characteristics at full speed was necessary, and that if possible this motor should be subject to definite speed variation. The multiphase motor, as known, gave better promise than the single-phase motor of fulfilling the conditions, and the multiphase elevator was, therefore, taken up first.

The elimination of noise, the obtaining of an excellent efficiency and power factor at full load, and the reduction of rotor weight and speed to the minimum, could be provided for in the design and manufacture of the motor. The starting torque and speed variation features did not so readily fall into line. The starting torque per volt-ampere was improved, but was not and has not as yet been brought to a point comparable with that of the direct-current motor.

Speed variation similar to that obtained by series armature resistance with direct-current motors was available, but, owing to the fact that in direct-connected elevator work, with a given live position of the controller, the motor may be driving the load or the load driving the motor,—depending upon the instantaneous relation between the car load and counterweight,—it is evident that such speed control is indefinite. Speed variation through a change in the number of poles in a single motor could be obtained, but, as already mentioned in connection with bringing the motor to rest, the use of this device entailed large starting current.

In elevator work the most important consideration is safety, and upon this the certainty with which the maximum speed may be limited and the elevator brought to rest has a direct bearing. The direct-current elevator is considered safe and it remains, therefore, to consider the difference between the application of direct current and alternating current to an elevator machine.

An induction motor has practically the same characteristics as the direct-current shunt motor, and, with all

A SINGLE-PHASE REPULSION-INDUCTION MOTOR BUILT BY THE WAGNER ELECTRIC MANUFACTURING COMPANY, ST. LOUIS, FOR ELEVATOR USE

resistance cut out of both primary and secondary circuits, the speed of the induction motor is limited quite as well by the number of cycles on the circuit as the speed of the direct-current motor is limited by the line voltage.

In the event of the line circuit being broken, however, the comparison ceases. Under such conditions the direct-current motor could retain a speed-regulating effect, while the speed of the induction motor would be limited only by the relation existing between the driving force and the mechanical friction opposing it. In small machines this mechanical friction has constituted such a large part of the load that but little difficulty has been experienced from runaways, though centrifugal devices have been added for further protection; but with higher duties the percentage of friction must decrease. It appears, therefore, that with highly efficient gearing and mechanical control, the failure of the current with the machine in operation or the lifting of the brake with no current on the line would prove a source of danger.

The obvious answer to this objection is that the introduction of an electric brake would at once overcome this difficulty, as an electric brake would refuse to release if there were no current on the line, and would immediately set itself in the event of current being shut off during the operation of the elevator; in fact, it would do so more surely than the electric brake on a direct-current machine. Safety, as well as convenience, demanded that an alternating-current magnet control should be available if higher speed or more efficient alternating-current work was to be undertaken, but its design was limited by many conditions.

The eminence of phase reversal on the line is not so apparent as it was some time ago, but it is clear that danger from this source on multiphase circuits exists and always will exist, and that provision should be made to nullify its effect. A device, which, in the event of reversal of phase relation, shall immediately open the supply circuit and apply the brake or prevent its release, thus bringing the elevator to rest if in operation, or preventing its starting if at rest, best meets this specification.

With some mechanical controls the current is cut off from the machine and the brake applied if the car passes the ordinary terminals of travel, and provision is made whereby the same two operations may at any time be performed from the car through some means other than the regular control.

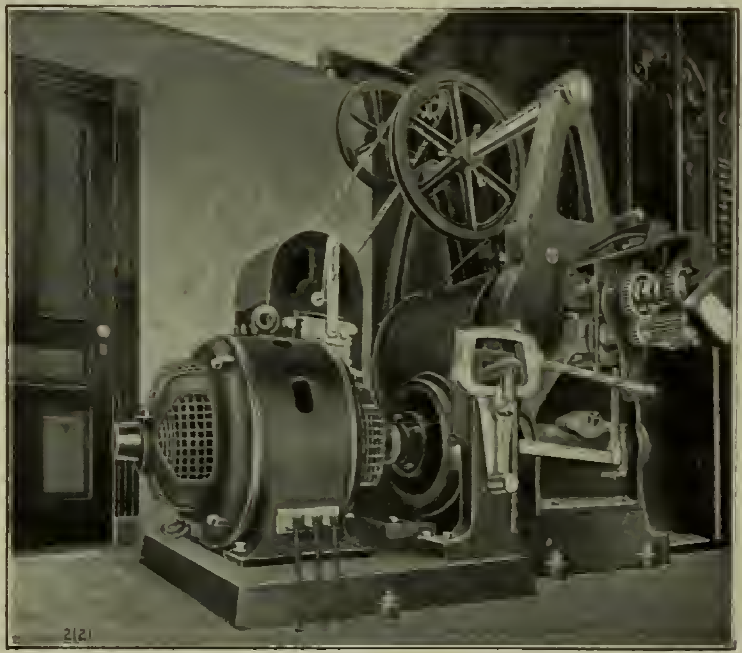
With a magnetic control, perhaps the best device for automatically accomplishing the desired result makes use of the torque principle of a small multiphase motor inserted across the main line circuit. With current across this small motor in the proper relation, the circuit to the elevator controller is complete, but at the instant the phase relation on the main line circuit is reversed, the direction of torque is reversed and the control circuit is, in consequence, opened.

This object may also be accomplished by various applications of direction relation between the power motor and parts of the control. Direction of movement of the control for desired direction of elevator is definite. Reversal of phase relation would disturb the relation existing between control and elevator direction. Devices mechanically or electrically operated, or operated in combination, may be applied to any part of the elevator system, whereby the elevator is brought to rest immediately this disturbance occurs.

It would seem, therefore, that with proper precautions safety may be assured. It may be of interest to know that the problem of magnetic control has practically been solved. Something over a year ago a multiphase magnetic control was set up and operated, and its action was positive. Chattering was obviated by the use of four-pole magnets acting on circular armatures.

For a two-phase circuit, two U magnets were set at right angles to each other, each having its pole tips the same relative distance from the common armature. Each magnet was wound for a separate phase and its strength varied with the alternations of the current. As one magnet was of maximum strength when the other was zero, and vice versa, and both acted on the same armature, the pull on the latter was constant, and as this armature carried the moving contact of the control, the contact it made was firm and constant. Furthermore, its attractive action was instantaneous and its release prompt. Magnets of this type may be made as large as desired, and are available for controls or for brake mechanisms.

For ordinary controls, a single-phase magnet of the solenoid type has been developed, which is simpler in construction and wiring, and lends itself more readily to the requirements of a control. Owing to the single-phase winding, the pull on the solenoid core is not steady, and if the contact were secured directly to this core it would chatter and the electrical contact



AN ELEVATOR HOIST OPERATED BY A WAGNER SINGLE-PHASE MOTOR

would be uncertain. To avoid this, the movable contact in the form of a copper disc is sleeved over an extension of the core and supported by a light spring. The energizing of the solenoid coil raises the core and completes the circuit through the movable and stationary contacts.

During the time the current is passing through the coil, the core has a longitudinal vibratory motion, due to the alternating nature of the current. The height at which contact occurs and the pressure of the spring are so adjusted that even when the core is at the lowest point of this movement, a firm electrical contact is maintained. This spring principle has also been applied to horizontal magnets with hinged armatures, but the vertical solenoid is the simpler type.

Accelerating magnets may be obtained by using the solenoid type in conjunction with dash-pots to furnish the time element, or by utilizing the differential action between two coils, one energized from the primary circuit, and the other from the secondary circuit of the motor.

With the controller magnets developed, the next step was to reduce the current required to release the brake, and, if possible, with safety, to provide that the brake-releasing current should not occur simultaneously with the peak of the motor-starting current. It must be remembered that a reduction in voltage on the line affects the torque of an induction motor very seriously, and the motor and the brake should be so related that it would be impossible to release the brake under operating conditions, unless the torque of the motor was sufficient to hold its maximum load.

This end has been attained by proper connections in the controller, and by the introduction of a momentum type of brake in which the turning effort produced when the friction shoes of the main brake grip the revolving brake-wheel is transmitted to the lever of a second brake which also tends to bring the moving parts to rest. As the braking effort is thus multiplied, a smaller brake magnet meets the requirements, and, in consequence, a smaller brake magnet current.

Utilizing these single-phase control magnets and a multiphase brake magnet, any form of "switch-in-car" or "push-button" control for a multiphase elevator may be obtained, without employing a rectifying process, and it is clear that this same combination is equally applicable to the control of a single-phase elevator by including a phase-splitting device to supply multiphase current to the brake magnet.

The single-phase elevator has not been developed to the same extent as the multiphase elevator, but the limitation is entirely in the motor. At present it is installed mainly for residence service, but higher duty seems quite possible.

Owing to its high starting torque, the single-phase motor which starts as a repulsion motor and runs as an induction motor seems to be the type best adapted to higher duty single-phase elevator service. There are a few elevators in this country thus operated and it is to be hoped that American motor manufacturers will continue the improvement of this type of motor.

Foreign manufacturers have succeeded in reducing the noise in the motor, and at present their machines appear to be in the lead so far as motors suitable for direct-connected elevators are concerned. They have also reduced sparking at the commutator without the use of high-resistance leads between the commutator bars and the armature coils, thus diminishing danger of burnout if the motor should fail to start promptly. Furthermore, with the American motor, starting resistance is employed, while from installations including foreign motors it may be eliminated.

Thus, while single-phase apparatus is still somewhat backward, with automatic elevators multiphase operative conditions have been met for a maximum speed of approximately 175 feet per minute and with switch-controlled elevators, a maximum speed of approximately 250 feet per minute, without the use of rectified current, and elevators of these types are now available. For automatic elevators the speed named meets all requirements, but for switch-controlled elevators a speed greater than 250 feet per minute is distinctly desirable.

That such higher speed service is obtainable with a machine which will meet commercial conditions, the writer is thoroughly convinced.

The starting current for an alternating-current motor suitable for elevator work is greater than that of a direct-current motor, but it seems reasonable to assume that in any location in which high-speed service is demanded, provision for a high starting current may be made. It was done when direct-current elevators were new and demanded large starting current, and it will be done for alternating-current elevators. It was justified then. It will be justified now.

It is not difficult to obtain a multiphase induction motor which shall have large starting torque, or one which shall have either good power factor, high efficiency, good speed regulation, low speed, stability, quiet operation or fairly low rotor weight, but to combine all these features in a single motor is an interesting problem.

Compromises must be made and a design which will insure the highest starting torque per volt-ampere and high efficiency at average load seems most fair to both central station and customer, and much has been accomplished toward obtaining a satisfactory motor along these lines. If no better performance can be expected from the motor, high speed apparently means heavy starting current, multi-motors or higher mechanical efficiency in the transmission between motor and load.

High-speed service requires some form of control for intermediate speed, in order that good landings may be made. The introduction of a double or multi-motor arrangement with provision for individual and cascade connection, or with one electro-dynamic machine arranged as a power consumer, appears to offer the best promise for definite speed control, but the introduction of the multi-motor also affects the starting torque required and obtainable.

By use of the cascade connection increased starting torque for the same volt-ampere input may be obtained, but in stepping from one set of connections to another the current jumps are apt to be large unless the control is complicated, and this situation has been quite thoroughly gone over in the application of the cascade connection to multiphase railroad work.

The cascade arrangement would permit efficient operation at the various speeds, and, during the first portion of speed reduction would produce a dynamic braking effect, but, on the other hand, any multi-motor arrangement must naturally increase the weight of the rotor necessary for a given full-speed duty, and the disadvantages of an increase in the weight of the high-speed parts of a direct-connected elevator may not be fully appreciated.

For the information of those who have not given thought to this phase of the subject, it may be well to state with an ordinary direct-connected machine, using both independent and drum counter-weight and arranged for a capacity of 2500 pounds at about 300 feet per minute, the inertia value of the high-speed parts, namely, the worm, brake-wheel and rotor, constitutes about 85 per cent. of that of the entire elevator equipment; in other words, of the excess torque necessary to accelerate the elevator to full speed when starting, about 85 per cent. is required to get the rotor, brake-wheel and worm up to speed, while the small balance of from 10 per cent. to 15 per cent. suffices to bring the car, load and counter-weights to speed.

If necessary, the efficiency of the

mechanism between the motor and the live load in the car may be increased, thus cutting down the running horse-power required of the motor, and, in consequence, the weight of the rotor. This reduces not only the torque required to move the load at constant speed, but also the torque needed to overcome inertia during acceleration.

Mention has already been made of two methods of reducing the maximum starting current by reducing and adjusting the brake current, and still another device includes the mounting of the stator of the motor in bearings concentric with the rotor bearings in such manner that it may revolve through part of a circumference, but, when not energized, will be held central between the limits of its arc of movement. The starting torque itself is thus made to release the brake through a cam on the stator, which acts upon the brake lever. This also provides for safety by interlinking motor torque and brake release, and includes in the same device the motion necessary for a phase reversal safety.

A type of accelerating device which has been advocated with particular reference to the acceleration of large units, employs a small direct-current generator and direct-current magnets. The generator is arranged to be positively driven by the elevator motor and is electrically connected to the accelerating magnets. Rotation of the motor is accompanied by corresponding rotation of the generator, and, as the electromotive force of the latter gradually increases, the accelerating switches consecutively short-circuit sections of rotor resistance until all starting resistance has been cut out. Current from this generator is also employed to assist in stopping, by passing it through an auxiliary brake-applying solenoid at the instant the operating circuit is opened. This is applicable to either multiphase or single-phase apparatus.

The direct-current type of accelerating device employing a magnetic clutch driven from the elevator motor, may be applied to an alternating-current elevator by substituting alternating-current magnets. Any resistance cut-out, mechanically driven and employing a magnetic detent and a holding magnet at the terminus of travel, may be made to accomplish the same object.

A non-chattering magnetic control may also be obtained by arranging for electrical contact through gravity or spring pressure rather than through the direct action of the control magnets. This may be accomplished by allowing the weighted core of a solenoid through which no current is flowing, to hold open the contact. When the coil is energized, the pressure due to the core is removed and firm contact is then established by the action of gravity, or by a spring.

A direct-acting single-phase magnet may be made to insure continuity of circuit by introducing sliding contacts. The vibraton due to the alternating current may move the contact, but it does not open the circuit.

Pilot motor controls may also be employed.

Compressed air may be applied to alternating-current elevator control substantially as in alternating-current railroad control.

For stopping, improved mechanical braking devices have been mentioned, and the dynamic action obtainable from multi-motor arrangements may be employed through all or part of the period of stopping, as well as for intermediate speed control. It is evident that the introduction of direct current into the windings in the stator of an induction motor, after the alternating-current supply has been cut off, will produce a dynamic action effective in stopping. With a multi-motor arrangement the application of this scheme to one of the motors is also available for intermediate speed control. The direct current required for this purpose may be obtained from a small direct-current generator mechanically driven by the elevator motor or from an exterior source.

It is no easy task to produce a high-speed alternating-current elevator that shall be satisfactory from every standpoint, but operative principles have been evolved and its development really lies in the hands of the central stations. Mechanically and electrically controlled elevators for low and medium speeds are now on the market, and the higher-speed machines will, it is believed, be obtainable if there is a persistent call for them. So long as the high-speed direct-current elevator meets the requirements, so long will the development of the high-speed alternating-current elevator be retarded, for this is a busy world and the work first undertaken is that which is easiest or that for which there is the greatest demand.

Operating with trolley current at 2200 volts, 25 cycles, a series single-phase electric railway system between Atlanta and Marietta, Ga., the first alternating-current line in the Southern States, was recently put into service.

A Large Private Branch Telephone Exchange

According to "The American Telephone Journal," the record for large private branch exchanges is held in Philadelphia, where Wanamaker's big store recently completed the installation of a branch exchange which has connected to it 2000 instruments. For handling the business a twelve-position switchboard is used, and telephones are installed at each counter. They are provided with automatic coin boxes, to insure payment for all outward messages, and may be used by customers, if desired. This is a distinct step beyond the use of the instruments only for the business of the store. One hundred and twenty trunk lines are in use to connect the branch exchange with the regular telephone system of the city.

A New Process of Making Metal-Coated Paper

A new process of coating paper with electrolytically deposited metal is given in a recent number of "Pulp and Paper." The anode of course is made of the metal to be deposited. On another plate is deposited a thin layer of the metal about 1-250 inch in thickness. Against this is placed a sheet of paper coated with a certain kind of glue. When this is dry the adhesion is strong enough to cause the metal to remain on the paper when the latter is torn off the plate. In this way gold, silver, and copper-coated paper has been produced.

One of the largest artificial storage reservoir hydroelectric power plants in the world is under construction on the River Sihl, in the Canton of Schwytz, Switzerland. A dam 90 feet high and 350 feet long will impound the water in a lake with a surface area of two square miles. The capacity of the reservoir will be 25,360,000,000 gallons. The generating plant will be upon the shore of Lake Zurich, and will be operated under a head of 1575 feet. It is estimated that a continuous supply for 20,000 horse-power will be afforded, or for 45,000 horse-power if operated only ten hours per day.

Fourteen automobiles are provided by the Cumberland Telephone & Telegraph Company, of Nashville, Tenn., for use by "trouble shooters" or installers.

Electrical and Mechanical Progress

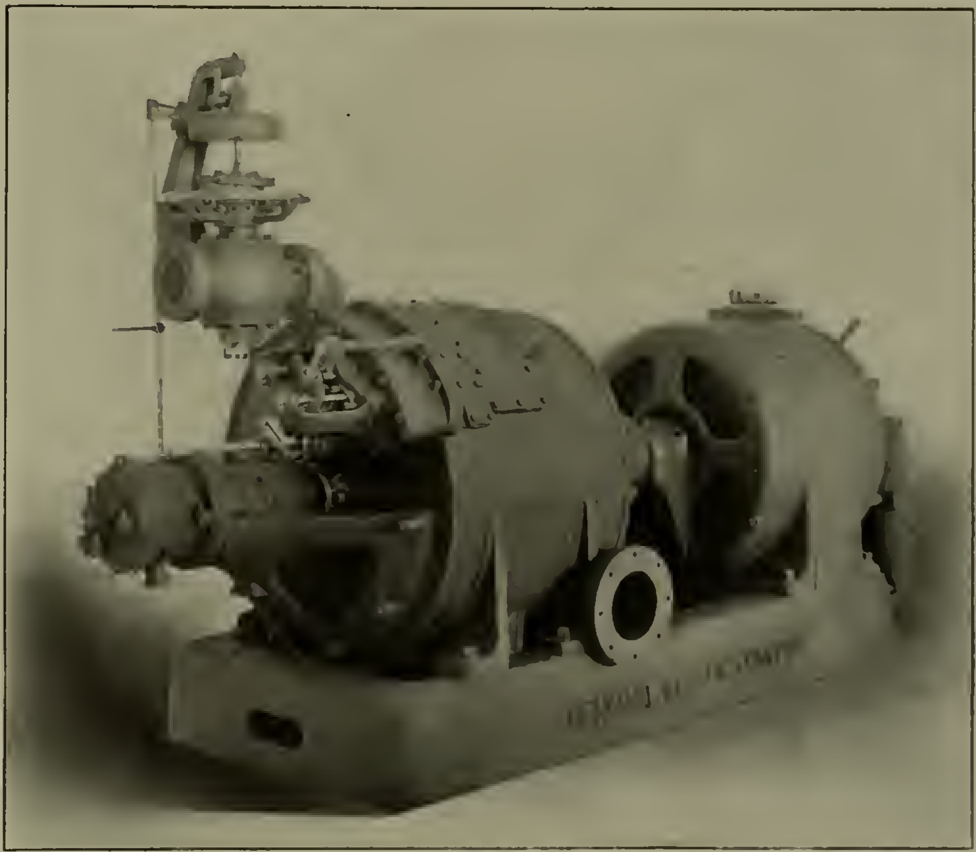
Small Curtis Turbines

THE success attending the use of small direct-current, horizontal type Curtis steam turbine generating sets, made by the General Electric Company, of Schenectady, N. Y., warrants a description of this type of electrical apparatus. Not only is this machine suitable for use where reciprocating - engine - driven generators have formerly been used, but on account of its compactness and simplicity of construction, it has been adopted for new uses.

This type of generating apparatus, it may be said, embodies all the good points of rotary motion. Vibration and wear are reduced to a minimum in the turbine. On this account the machine may be placed on light and inexpensive foundations, and on account of the compactness of the entire set, it is well adapted for train lighting, as an exciter in generating stations, and for auxiliary power of all kinds where small space and quiet running, as well as minimum expense for installation, are of importance. Machines of this type are built for these purposes in sizes from 15 to 300 kilowatts, for operating either condensing or non-condensing at pressures ranging from 80 to 200 pounds in the smaller sizes and from 100 to 200 pounds in the larger types, without reducing valve and at any degree of superheat up to about 200 degrees Fahr., without danger of injury.

Another important advantage of the steam-turbine generator set is the small number of bearings, namely, the main shaft bearings and the link between governor and valve. In the smaller sizes of turbines the bearings are supplied with oil by the usual oil rings and wells of ample proportions. In the larger sizes a closed oiling system is used, provided with an oil circulating pump, which is shown at the right of the accompanying illustration. Since the system is closed, there is no waste of oil from spattering or other causes. No internal lubrication is necessary in the Curtis steam turbine, and, as a result, the exhaust steam can be used in heating systems or in manufacturing processes, as it is entirely free from oil.

The speed of the turbine is held constant by a centrifugal governor which controls the steam supply entering the turbine. A uniform speed is obtained, irrespective of load conditions. In addition to the regular governor, an emergency governor is supplied which shuts off the steam, if for any reason the speed should rise a certain percentage above that fixed as normal. This entirely eliminates any danger of excessive speeds.



A SMALL CURTIS STEAM TURBINE GENERATING SET BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

On account of the rugged construction of the Curtis turbine, it is not subject to injury in case it is by accident flooded with water.

The generators in these turbine sets gain indirectly in compactness because of the higher operating speeds, and the cylindrical design of the turbine suits exactly the compact, well-proportioned electrical unit.

From their compactness and absence of vibration, the small Curtis steam-turbine sets have found a wide field in electrical train lighting, mounted either on the locomotive or in the baggage car, as exciter sets in power houses, and for small power and lighting installations. Being easily and quickly located in an odd corner, they have been found exceptionally well adapted for auxiliary units in manufacturing establishments. In the smaller sizes the set makes an ideal unit for marine work.

Motor Drive in a Cotton Mill

THE application of electric motors to the operation of textile mills has proved conclusively that by this method of drive economies are obtained which are not possible with any other method, such as increased quantity of goods manufactured, as well as the elimination of heavy belts and shafting.

In the cotton industry the rapidly increasing demand for electrical equipments is especially noticeable, one illustration being a recent order from the Dan River Power & Manufacturing Company, Danville, Va., for their new plant, placed with the Baltimore office of the Westinghouse Electric & Manufacturing Company, of Pittsburg.

The contract is practically a duplicate of the present installation which has been in operation about eighteen months. The new plant, when completed, will be one of the best electrical installations for cotton mill work in the country. The mills were designed by the well-known firm of Lockwood, Green & Co., of Boston, and have the latest type of cotton mill machinery driven by induction motors.

The power plant is on the Dan River about a mile distant from the mills, and will contain, when completed, three 750-KW. and three 500-KW., alternating-current, revolving-field generators of the water-wheel type, with two 125-KW., direct-current exciters and complete switchboard equipment.

The recent order for new apparatus includes one 750-KW., revolving-field, 6600-volt, 25-cycle, 3-phase water-wheel generator; two 500-KW. generators of the same type; switchboard equipment; a bank of three 600-KW., oil-insulated, water-cooled transformers complete with oil controlling switch; a low-tension switchboard, and twenty-four 440-volt, 3-phase induction motors, which will be used for operating the machinery in the cotton mills. The sizes of the motors are as follows:—Fourteen 100 H. P., five 150 H. P., two 50 H. P., two 40 H. P., and one 75 H. P.

Testing Overhead Catenary Construction

SOME interesting tests were recently made on a 1000-foot catenary line erected at Reading, Pa., by Elmer P. Morris, 51 Dey street, New York, representing the Electric Railway Equipment Company, of Cincinnati, Ohio, to determine whether a system of this nature was practicable for service such as that to be required on the electrified section of the West Shore Railroad between Utica and Syracuse.

Two sections of catenary were erected,—one 300-foot span, and one 350-foot span. The poles were made of tubular iron in three sections; the bottom section was 10 inches in diameter, the middle section, 9 inches, and the top section, 8 inches. Each of the three poles used measured 40 feet 6 inches from the ground up, or 48 feet over all, and weighed 2700 pounds. The middle pole was placed under normal working conditions by securely anchoring the end poles of the line. On the side it was guyed with a 5-16-inch cable attached to a Miller anchor.

Three No. 0 equivalent aluminum

FIG. 1.—GENERAL VIEW OF THE EXPERIMENTAL LINE FOR TESTING OVERHEAD CATENARY CONSTRUCTION, ERECTED BY ELMER P. MORRIS, NEW YORK, REPRESENTING THE ELECTRIC RAILWAY EQUIPMENT COMPANY, CINCINNATI, OHIO

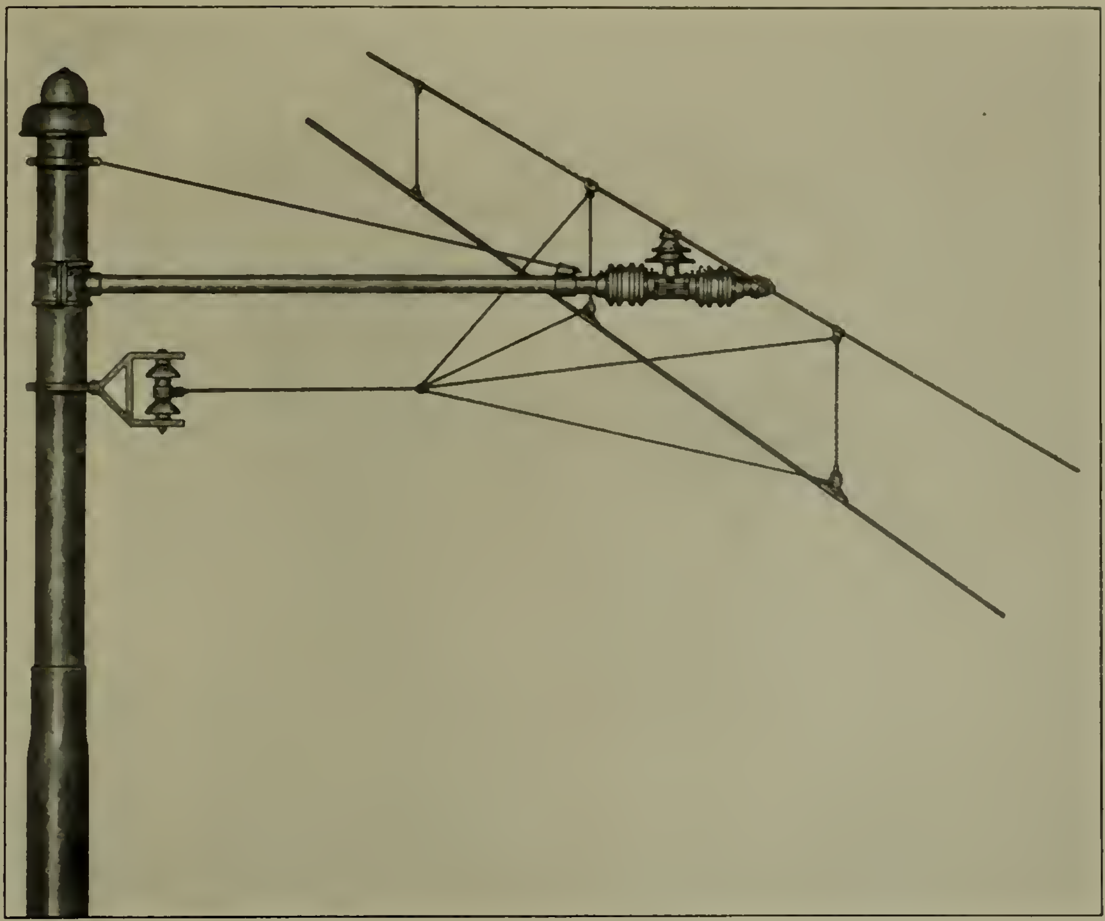


FIG. 2.—CATENARY CONSTRUCTION IN WHICH A BRIDLE GUY IS USED

cables were mounted at the top of the poles in the form of a triangle, with the apex uppermost. Below these, a 500,000-circular mil copper feeder cable was placed, and on a 12-foot pipe bracket containing a catenary insulator were hung the messenger wire and the trolley wire. Fig. 1 shows a general view of the experimental line thus constructed.

The insulators used for the messenger wire were of the usual high-tension type about 9 inches high, and were tested for 80,000 volts. In order to catch the messenger wire in case the main insulators should break, porcelain insulating spools were slipped over each bracket arm and secured directly under the main insulator.

For this form of construction, Mr. Morris has secured broad patents. The advantages claimed for it are:—Non-interference with the service in case of a main carrying insulator breaking; prevention of the messenger wire coming in contact with the supporting iron arm; the messenger wire may be composed of copper cable and used as a feed wire instead of the usual practice of thoroughly insulating the messenger wire from the trolley wire.

The catenary cable used in the tests was hung with a dip of 5 feet 5 inches, and suspended from it was a No. 0000 grooved trolley wire. Spreaders like the one shown in Fig. 5, and composed of a flat steel strip, $\frac{1}{8}$ inch by 1 inch, and of different lengths to suit the catenary curve, were used for the suspension; these were spaced 10 feet apart, and were fastened to the trolley wire by drop-forged ears and to the messenger wire by clamps.

It is intended in future work of this kind to use a bridle, as shown in Fig. 2, to strengthen the construction. This bridle is made of steel rods, centering in a common ring, which is secured to the pole by a steel rod. It thus serves as a side guy for both messenger and catenary, and in case of a break in the messenger wire would prevent the damage extending beyond one span length.

In one of the tests made, a 7-16-inch cable was fastened to the top of the pole and led off in a direction opposite to the bracket for a distance of 125 feet to the ground. At this distance a strain of 2050 pounds was put on the pole. As shown in Fig. 3, the pole was pulled slightly out of the perpendicular. This was apparently due to the poor resistance offered by the earth to the concrete foundation, which was about 3 feet in diameter.

The pole was then pulled back to its normal position, so that the guy rope was again tight, and a downward strain of 2000 pounds was put on the end of the bracket directly below the catenary. This test pro-

FIG. 3.—THE POLE WAS DEFLECTED AS HERE SHOWN UNDER A STRAIN OF 2050 POUNDS AT THE TOP, EXERTED AT A DISTANCE OF 125 FEET

FIG. 4.—APPEARANCE OF THE EXPERIMENTAL LINE UNDER A DOWNWARD STRAIN OF 2000 POUNDS ON THE END OF THE BRACKET

duced a permanent set of about 3 inches in the bracket, as shown in Fig. 4. the set causing the bracket

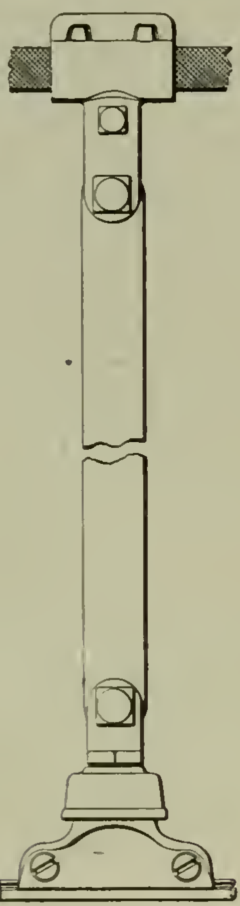


FIG. 5.—SPREADER MADE OF FLAT STEEL STRIP

to become slightly bow-shaped between the pole and the end of the tie rod.

The next test consisted in cutting the trolley wire at the middle of the 350-foot section. The result was that the wire slacked a trifle, the ends hanging a few inches below their normal horizontal position.

In the final test, the trolley wire was first cut and then the catenary was severed at the dead end stud This caused the bracket on the first pole to spring 90 degrees out of position, and the casting on the under brace to break. The bracket on the middle pole behaved in the same way as that on the first pole, except that it did not turn as far and did not break. The bracket on the third pole remained in its normal position and held the catenary on the insulator.

As the brackets were all fastened to the poles by means of split collars, this test produced no torsion on the poles, as the collars that moved simply turned on the poles. The estimated strain on the bracket, assuming the weight of the structure at two pounds per foot, was about 5700 pounds. At the end of the last test, the entire catenary and trolley in the two full spans lay on the ground.

Blast-Furnace Gas-Engine Development in the Pittsburg District

THE Carnegie Steel Company recently contracted with the Westinghouse Machine Company, of Pittsburg, for a gas engine to utilize surplus gas from their furnaces for the generation of power needed in the electric driving of mill machinery.

Some time ago the Carnegie Steel Company contracted with the Westinghouse Machine Company for some large blowing engines to be driven by blast furnace gas. For the purpose of conducting preliminary experimental work, an engine of 350 H. P., running at 150 revolutions with 30-inch stroke, was installed, and two gas blowing engines, the largest ever built in this territory, are now under construction at East Pittsburg for the work at the Edgar Thompson furnaces, at Bessemer.

The gas engine for electric generation will be similar in design to the blowing unit, and will drive a direct connected generator for the purpose of augmenting the present power service at the Bessemer works. The gas engine will develop approximately 2500 brake-horse-power on blast furnace gas. The generator will be a 1500-KW., direct-current machine connected in parallel with the other steam machinery at the present Edgar Thompson power plant.

Vertical Single-Phase Self-Starting Motors

TO meet the rapidly increasing demand for vertical single-phase self-starting motors, the Century Electric Company, of St. Louis, Mo., have designed a line of such motors, ranging in size from ½ to 5 H. P.

One of these motors is shown in the accompanying illustration. The standard winding is for 104 or 208 volts, interchangeable, but the motor can be wound for any voltage up to 500. The motor can be belted, geared, or direct connected to a vertical shaft, and when so desired can be equipped with feet or legs at the side, so that it can be attached to any vertical support. As a whole, it is well protected, and at the same time is well ventilated. Ball bearings are used to take the end thrust.

These motors are designed for operating centrifugal pumps, and for house service and irrigation.

A VERTICAL SINGE-PHASE SELF-STARTING MOTOR BUILT BY THE CENTURY ELECTRIC COMPANY, ST. LOUIS, MO.

They are entirely automatic in operation, and can be started and stopped with an ordinary float switch.

The Electrical Works of the Allis-Chalmers Company

THE electrical works of the Allis-Chalmers Company are located at Norwood, a suburb of Cincinnati, Ohio, and comprise the original model plant of the Bullock Electric Manufacturing Company, with extensive additions which have been and are being made in order to provide adequate facilities to meet the rapidly increasing demand for space. Electrical generating, transforming and driving apparatus of every type is built here, including direct-current dynamos and motors, alternating-current generators, induction motors, transformers, rotary converters, railway motors, air-brake motors, controllers, switchboards and a great variety of auxiliary apparatus.

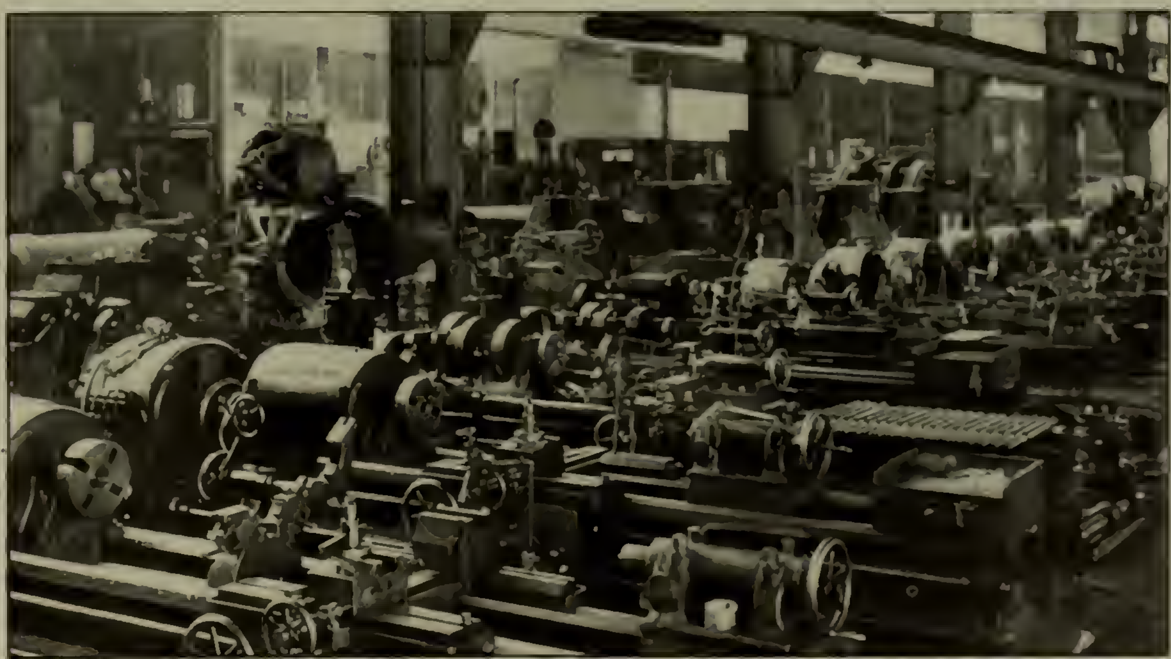
The plat of ground on which the works have been built is approximately sixteen acres in area. All the main buildings are of modern iron, steel and brick or concrete construction, exceedingly well lighted and ventilated. As a group, the buildings of this plant present an appearance which is far above the average, being faced with buff-coloured pressed brick. All buildings with the exception of the foundry are provided with wide and well-kept grass plots between the pavement and the building proper. The foundry is equipped with two cupolas, with a capacity each of 12 tons per hour. The main bay is served by two electric traveling cranes of 25 and 15 tons' capacity, respectively. Each of the side bays is served by a smaller 5-ton crane. Coke heated core ovens are employed for the treatment of cores and moulds.

In the pattern shop and pattern storage building the slow-burning mill type of construction has been followed, the floors being of heavy timber, with no openings of any description. A tower in the rear of the building contains the elevator, staircase and main electrical wiring. There are no openings from this tower directly into the various floors of the building, but at each landing a fireproof sliding door leads into the main building. Each floor consists of a single large room, the two upper ones being provided with suitably numbered racks for storing patterns.

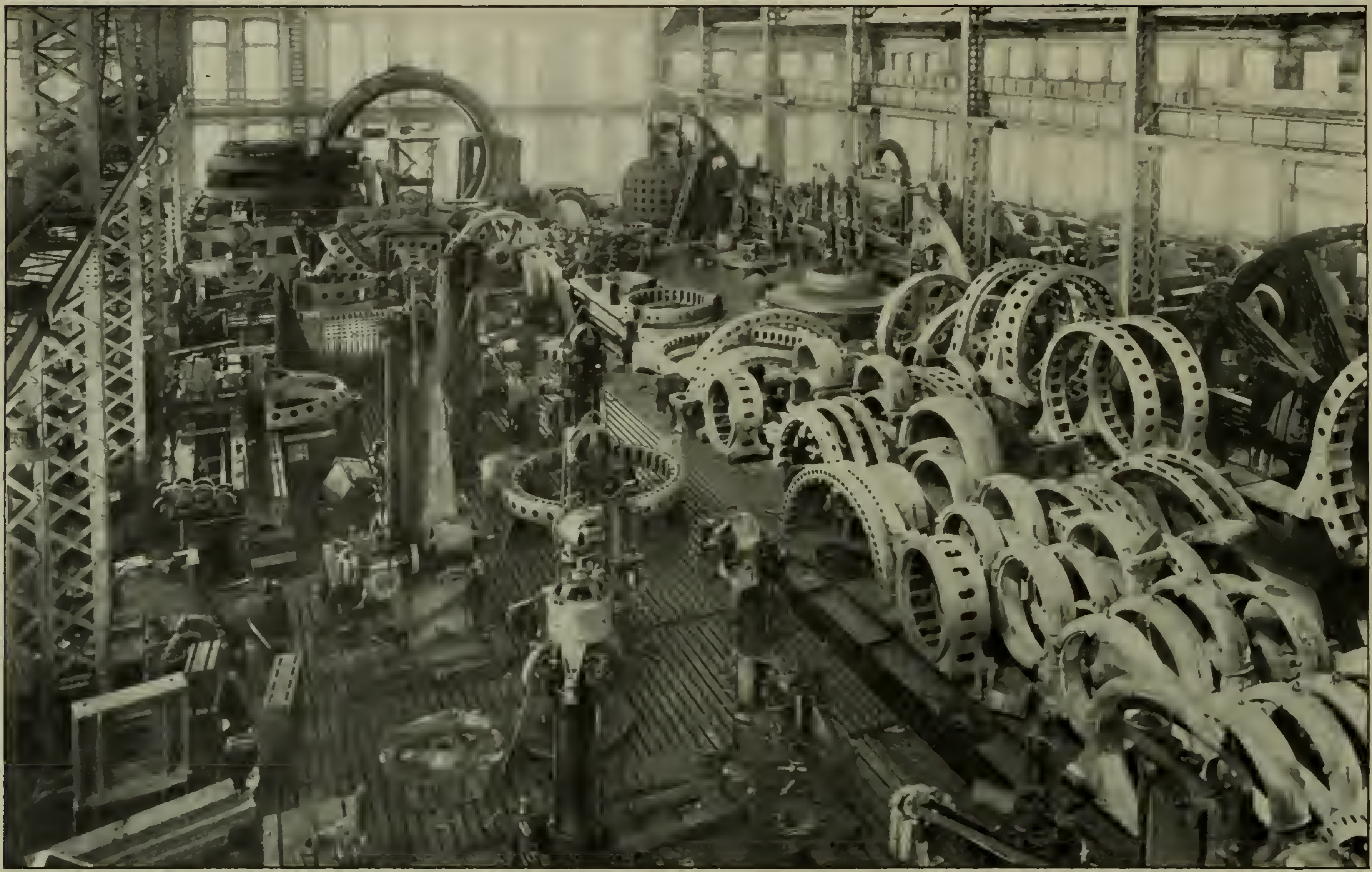
The first floor is used as a storage room for small dynamos and motors carried in stock. The second floor is used as a pattern shop, providing room for forty pattern makers. The most approved forms of woodworking machinery comprise the equipment, each tool being driven by an individual electric motor.

Machine shop No. 1 is one of the original Bullock buildings. The equipment throughout is composed of motor-driven machine tools of all kinds used in the manufacture of electrical apparatus. The building is identical in general appearance and construction with the others of the group. The central bay is served by two cranes of 20 and 30 tons ca-

MACHINE SHOP NO. I AND POWER HOUSE OF THE ALLIS-CHALMERS ELECTRICAL WORKS AT NORWOOD, A SUBURB OF CINCINNATI, OHIO



INTERIOR OF ALLIS-CHALMERS' MACHINE SHOP NO. 1, SHOWING MOTOR-DRIVEN LATHES



INTERIOR OF ALLIS-CHALMERS' MACHINE SHOP NO. 3, SHOWING PORTABLE MOTOR-DRIVEN TOOLS AND FLOOR PLATES

pacity, respectively, and the side bays each by a 5-ton crane. In addition to the machine tool work performed in shop No. 1, a portion of the armature winding for large machines is carried on here, and a testing department for the smaller machines has been provided in the front portion of the building. The Allis-Chalmers motors, used to drive the machine tools, are operated on the multiple voltage system of variable-speed control.

In each machine shop there is a separate balancer installed for splitting the voltages, and which may be used independently in case of the failure of those installed in either of the other shops. The connections of these balancers are such that one set may be made to carry the load of the others.

Machine shop No. 2 is identical in general appearance with the other buildings of the group. A 5-ton electric traveling crane serves the entire length of the shop. An industrial railway connects the punch department with the annealing department. At both ends of the shop freight elevators, driven by electric motors, connect the upper and lower floors. The drying ovens are also connected directly with the insulating department by a similar elevator.

On the first floor is located the punching department where the sheet steel punchings for armatures and field poles are made. This shop is provided with a complete equipment of motor-driven punch presses. On this floor the armature cores for direct-current dynamos and motors, and the stator cores for small alternating-current machines are assembled. The commutator department is located at the rear, and in a room separated from the remainder of the building by fireproof walls, the punchings for armature and stator cores are annealed and japanned. The upper floor of shop No. 2 contains the coil winding department where armature, field and transformed coils are wound and insulated.

In this shop, every machine tool, from the ponderous drill presses, making laminations for turbo-generators, to the small tapping machines for insulating armature coils, is driven by an individual electric motor.

Both upper and lower floors of shop No. 3 are divided into bays by rows of columns, and on the lower two, 10-ton cranes are provided; the work on the upper floor being of a lighter character, two 5-ton cranes are installed. An elevator is located at about the middle of the extension.

On the second floor are the tool room and brass department for the manufacture of small brass parts entering into the construction of machines. The front portion of this unit is used for the construction of large machines and is divided into three bays. Each side bay is 48 feet wide, one served by a 20-ton crane, and the other by one of 30 tons capacity. Part of the central bay is provided with iron floor platens for the use of portable drills, slotters, etc.

The works power house and boiler plant are located alongside of shop No. 1. The power-house equipment consists of two Allis-Chalmers 800-KW., 240-volt direct-connected engine-type generators, one of which is driven by a Lane & Bodley engine, and the other by an Allis-Chalmers Reynolds cross-compound Corliss engine. There is further equipment consisting of a small 100-KW. unit and an air compressor outfit used for operating pneumatic tools used in various operations throughout the shops. Two artesian wells furnish the entire water supply for engines and fire service. A water storage reservoir is provided for use in fire, with a fire pump in connection with a complete sprinkler system for all buildings. The engines are run non-condensing.

The boiler-house equipment is comprised in six 250-H. P. Cahill vertical water-tube boilers, fitted with Mansfield chain-grate stokers.

In the service building a wire storage room and locker, and wash rooms for employees, occupy the lower floor. The upper floor is fitted up as a dining-room for factory and office employees.

The administration building provides accommodation for the various administrative offices and departments, drafting room, engineering department, purchasing department, superintendent's office, etc.

In addition to the standard gauge railroad tracks in yards and buildings, complete equipment of narrow-gauge industrial railway interconnect the various shop units. All the yard track is equipped with overhead trolley, and motor-driven cars equipped with electrically operated jib cranes are used for loading and unloading material and conveying it between the shop buildings.

An Up-To-Date Isolated Plant

THE electrical equipment of modern office and mercantile buildings has attained far greater proportions than is generally known. Aside from illumination, there is a broad field for electric motors, their practically noiseless operation, cleanliness and compactness, rendering them especially applicable to general power work, such as operating ventilating schemes, refrigerating appliances, elevators, water and sewage pumps, and the many classes of apparatus that make up the equipment of large buildings.

There are also many applications for electric motors in the boiler and engine rooms of isolated plants. The high value of real estate in large cities generally necessitates locating the power plant in the basement or sub-cellar, where natural ventilation is poor and space is reduced to a minimum. Under such conditions it is essential to have the machinery arranged as compactly as possible, and motor drive is the natural solution of the problem of operating ventilating fans, coal conveying apparatus, stokers and pumps.

To illustrate practically the applications enumerated, a description of the central power plant of the estate of Henry W. Oliver, of Pittsburg, Pa., will be both interesting and instructive. It is located in the heart of the city's business center and furnishes light, heat and power to several large office buildings and churches, the McCreery department store, Duquesne Club, and a number of similar consumers.

This isolated plant has a total of 1459 KW. wired in load, which, with contemplated extensions in the near future, will ultimately be increased to approximately 2900 or 3000 KW. The three-wire, direct-current system of distribution is used, with an electromotive force of 220 volts between outside mains, and 110 volts between each main wire and neutral.

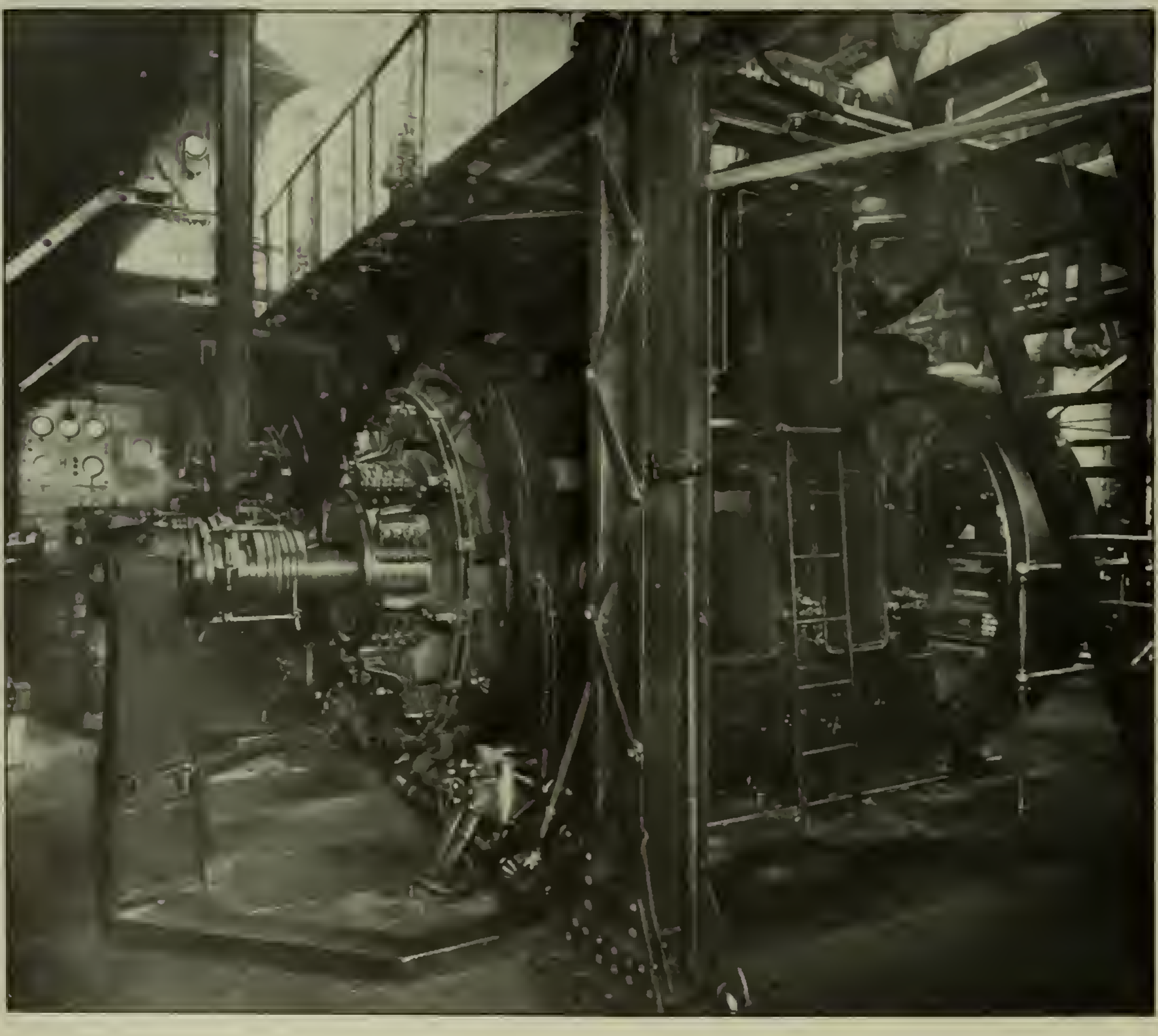
Babcock & Wilcox boilers having a total capacity of 2000 H. P., are used. These are divided into four batteries of 500 H. P. each, operating at a pressure of 150 pounds. Each boiler is provided with chain grates made by the Green Engineering Company, of Chicago, Ill.

The coal is elevated from the storage bins to a traveling hopper by means of a coal conveyor. Scales in the cage beside the hopper provide a means for weighing all coal used. Both the conveying apparatus and traveling hopper are operated by electric motors, and are easily and quickly handled. The hopper travels on an elevated track the length of the boiler room, and is controlled from the floor by the fireman.

The generating units consist of three 200-KW., 220-volt, direct-current, three-wire generators built by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., and direct connected to three Ball vertical twin-compound engines of 325 H. P. each, built by the Ball Engine Company, of Erie, Pa., and operating at an approximate speed of 190 revolutions per minute; and one Westinghouse 375-KW. generator of the same type connected to a Ball-Corliss type vertical cross-compound engine of 600 H. P., operating at 130 revolutions per

THE BABCOCK & WILCOX BOILERS IN THE CENTRAL POWER PLANT OF THE ESTATE OF HENRY W. OLIVER, PITTSBURG, PA., ARE PROVIDED WITH CHAIN GRATES MADE BY THE GREEN ENGINEERING COMPANY, CHICAGO

THE REFRIGERATING APPARATUS IS DRIVEN BY WESTINGHOUSE MOTORS



WESTINGHOUSE THREE-WIRE, DIRECT-CURRENT GENERATORS FURNISH CURRENT FOR THE OLIVER ESTATE

minute. The main features of the three-wire generators are the same as those of an ordinary direct-current machine, with the addition of four slip rings, which are connected to the armature winding by taps at four electrically equidistant points for each pair of poles. From these rings wires are carried to balancing coils with their middle points connected together to form the neutral of the system.

The unbalanced current in the armature is practically evenly distributed, and the machine will operate satisfactorily with a 25 per cent. unbalanced load.

Current is transmitted by lead-covered cables to the switchboard, which is of the standard Westinghouse three-wire type with panels of white marble. Two ammeters are used with each generator so that the load on both sides of the system may be observed. A double-reading ammeter is connected in the neutral of each machine to show the amount of unbalanced load. A voltmeter connected across the main bus-bars indicates the potential at all times, and a second voltmeter arranged to be connected to each motor by four-point voltmeter receptacles, enables the operator to adjust the voltage for paralleling. Two double-pole generator switches, two double-pole balance coil switches, and a shunt field rheostat, complete the equipment of each generator panel.

The balance coils are located conveniently upon a shelf near the end of the switchboard. Feeder panels are provided with instruments similar to the generator panels, with the exception of the field rheostat and balance coil switches. A load panel is provided for measuring the total output of the station, upon which are mounted a recording voltmeter made by the Bristol Company, of Waterbury, Conn., two recording ammeters of the same make, and a switchboard type integrating wattmeter.

The distribution system is quite extensive. A tunnel extends from the power plant to the McCreery and new Smithfield street buildings for carrying cables, steam and fire lines, refrigerating and cold water pipes. The balance of the consumers are supplied with cables run in underground conduits.

The McCreery building uses 775 KW., supplying twenty-seven electric motors ranging from ½ to 50 H. P., 486 arc lamps, 926 16-candle-power, and 600 8-candle-power incandescent lamps. The feeders for supplying current for this load are composed of 2370 feet of lead-covered cable, 1,600,000 c.m. in area; 2340 feet of lead-covered cable, 1,400,000 c.m. in area; and 7941 feet of paper insulated cable, 1,000,000 c.m. in area; all manufactured by the Standard Underground Cable Company, of New York.

The Smithfield and Wood Street properties are supplied by 4620 feet of lead-covered cable, 1,000,000 c.m. in area, each leg being approximately 250 feet long, for supplying the balance of the consumers. The cables are all supported by the latest improved methods and present a very neat appearance.

The refrigerating apparatus for furnishing refrigeration to the McCreery store, kitchen, and to the drinking water for the building is located in the rear of the switchboard in the power plant. The absorption system, manufactured by the Carbondale Machine Company, of Carbondale, Pa., is used. In connection with the refrigerating plant, there are two Dean Holyoke triplex water pumps, two brine pumps made by the same company, and three ammonia pumps made by the Gould Manufacturing Company, all of which are driven by Westinghouse motors ranging in size from 3½ to 15 H. P., inclusive, by means of Morse silent chain.

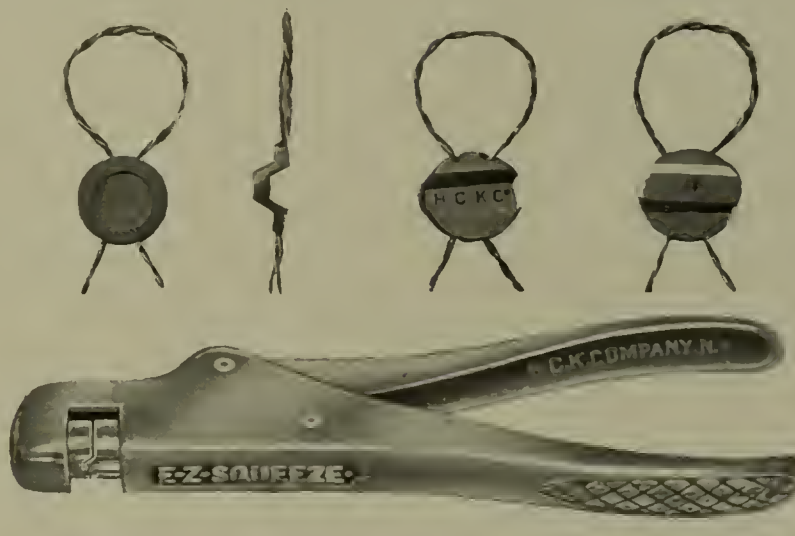
Exhaust steam from the engines is utilized in the absorption system of refrigeration to evaporate the ammonia, which is in the form of a liquid or a 26 per cent. solution. The steam circulates in pipes through the solution, causing the free ammonia to pass upward through a series of perforated baffle plates for draining off moisture; after passing through coils for further draining, it is carried into a cylinder containing coils of pipe, through which the brine circulates, the ammonia absorbing the heat therefrom.

There are several interesting motor applications in the McCreery Building, among which may be mentioned a 30-H. P. constant-speed Westinghouse motor, operating a cold-air fan for ventilating purposes; two 8-H. P. Westinghouse type S, 220-volt motors operating elevator safety devices; and a 25-H. P. Westinghouse constant-speed motor, driving a sewage pumping outfit to raise the building sewage to the level of the street mains.

A New Lead-Seal Press

A NEW lead seal press, manufactured by the H. C. K. Company, of New York, for stamping seals on electric and gas meters, service boxes, fare registers, and freight and baggage cars, is shown in Fig. 2. It is of malleable iron, the zigzag-shaped dies being made of tempered steel.

One important feature of the press is that it fastens the lead seal to the wire in such a way that it is absolutely impossible to open the seal without cutting the wire. The initials of the owner can be sunk in the lower die. When several presses are required by one company, they are usually numbered consecutively, and the number or figure is sunk in the upper die of the press. The initials and numbers will then appear raised on each lead seal, as shown in the two right-hand views in Fig. 1. The two views at the left in Fig. 1 show the front and side of a seal before an impression.



FIGS. 1 AND 2.—LEAD SEALS BEFORE AND AFTER AN IMPRESSION, AND THE NEW LEAD SEAL PRESS MADE BY THE H. C. K. COMPANY, NEW YORK

Central stations and railway companies have found it advantageous to number each press. Each employee is then held responsible for his press and for all seals bearing his identification number. The importance of this system of meter, fare register, and car sealing should be appreciated by superintendents and managers who may otherwise have difficulty in locating the employee who last applied the seal.

Single-Phase Equipment for the Richmond & Chesapeake Bay Railway Company

IN the early days of electric railroading, Richmond, Va., was among the first to install a street railway. In the year 1888 the Sprague system was successfully operated in the city on a commercial basis. This glimpse of early railroad history is interesting, because Richmond is adopting the latest development in railway traction, the single-phase, alternating-current system.

To this end, the Richmond & Chesapeake Bay Railway Company has been incorporated, and, in accordance with its plans, about fifteen miles of track will be equipped immediately with single-phase apparatus. Eventually this single-phase road will extend from Richmond to Chesapeake, but the portion about to be electrified comprises that part lying between Richmond and Ashland. The contracts for the equipment of this section have been let to the General Electric Company, of Schenectady, N. Y.

The line in general will follow the plans which several roads in the Middle West have adopted, but the trolley voltage will be higher. The catenary method of suspension will be used, adapted for a trolley potential of 6600 volts. Each of the cars will be equipped with four single-phase motors. The Sprague-General Electric system of multiple-unit control will be used. The air-brake system will be of the combined straight and automatic type with motor compressors.

Power for the operation of the new road will be furnished by the Virginia Passenger & Power Company, and the arrangements for furnishing the single-phase current are of especial intesest. Two generating sets will be furnished, both to be operated ordinarily by water power, but arranged for electrical drive when that is necessary. The first unit will consist of a 750-kilowatt, 6600-volt, 3-phase, 25-cycle generator, mounted on the same shaft with a 750-kilowatt, 2300-volt, 60-cycle, 3-phase generator, the shaft being extended at one end for connection with a water-wheel of sufficient power to drive both generators at their rated output.

The second set will be made up of a 25-cycle, 6600-volt generator, a duplicate of the first; but instead of being mounted with a 60-cycle machine, this generator will be mounted on the same shaft with a 750-

KW., 550-volt, direct-current machine. When there is sufficient water to operate all the water-wheel generators in the station, these sets will be driven by the water-wheels; if, at any time, there is sufficient water to drive the generators, or flood conditions render it advisable to close the gate valves, the sets will be disconnected from the wheels and operated as straight motor generator units. The 60-cycle generator will run as a 60-cycle synchronous motor and the 550-volt machine will operate as a direct-curent motor.

Power for driving the motor end of the 25-cycle sets in this way will be obtained from the engine-driven units of the Virginia Passenger & Power Company already installed. When the motor-generator units are operated as water-wheel-driven machines, the 60-cycle generator will be operated in parallel with the present 60-cycle machines, and the 550-volt machine in the other set will run in multiple with the present 550-volt machines. The 750-kilowatt, 25-cycle generators in each set will, for the present, be operated as single-phase machines and will supply current directly to the trolley of the Richmond & Chesapeake road at 6600 volts.

In addition to the main apparatus outlined for the road, there will be a lighting station at Ashland. This will have a 100-kilowatt, 2300-volt, 60-cycle, 3-phase generator mounted upon a common base with a 150 H. P., 440-volt, 25-cycle, single-phase induction motor. This set will be operated from the 6600-volt trolley through a 150-kilowatt, single-phase, oil-cooled transformer. The motor-generator set will be provided with a direct-connected exciter mounted on an extension of the shaft.

The Richmond & Chesapeake Bay road will practically parallel the Richmond, Fredericksburg & Potomac steam road from Richmond to Ashland, and it is the intention of the trolley company to maintain a fast schedule between these two points, operating cars at very frequent intervals.

A New Feeder Support

In the May number of The Electrical Age, it will be remembered, a new feeder support, manufactured by the Coleman J. Mullin Company, of Brooklyn, was illustrated and described. Unfortunately, through a mistake of the printer, the illustrations were not placed correctly; they should be shown in the reverse position.

Trade News

The Allis-Chalmers Company, of Milwaukee, Wis., recently received an order from the Tanana Electric Company, of Fairbanks, Alaska, for four induction motors, one 10 H. P., one 15 H. P., and two 20 H. P. A few of the more important recent orders for reciprocating engines are the following:—International Paper Company, of New York City, four 22 by 42-inch Reynolds "Reliance" Corliss engines; the Republic Iron & Steel Company, Thomas, Ala., four 44 by 84 and 84 by 60-inch cross-compound, disconnected type vertical blowing engines; the Waterbury Rolling Mills, Waterbury, Conn., one 22 by 48-inch Reynolds heavy duty Corliss engine; the Rockdale Improvement Company, Rockdale, Tex., one 14 by 30-inch Reynolds "Reliance" Corliss engine; the Winona Copper Company, Houghton, Mich., one 16 and 30 by 36-inch Reynolds heavy duty cross-compound Corliss engine, one 250-KW. Allis-Chalmers generator, and one 15-KW. exciter.

Fairbanks, Morse & Co., of Chicago, have recently sold a large number of their standard mine cars to the Republic Iron & Steel Company, Nassau Ore Company, La Rue Mining Company and the Rhodes Mining Company, for use in these companies' large iron mines in Minnesota. The San Francisco offices of the company have been transferred to temporary headquarters at 969 Broadway, Oakland, Cal., until they are able to return to their permanent location in San Francisco, where they were recently burnt out in the disastrous conflagration following the recent earthquake. Meanwhile, customers are receiving the customary prompt attention.

The General Electric Company, of Schenectady, N. Y., which established its main Pacific coast office in the Union Savings Bank building at Oakland, Cal., immediately after the San Francisco disaster, as well as a local office at 1759 Geary street, in the burned city, has already leased a suite of rooms in the new Monadnock building, which they expect to occupy about June 15, 1907. For handling the present business, a half block of land has been leased in Emeryville, in close proximity to both the Santa Fe and Southern Pacific Railroad tracks. A temporary building is now about completed on this land for taking care of stock, and work has already been started on a new warehouse, containing about 80,000 square feet, which will be located at the south end of the block bounded by Kansas, Rhode Island, Fifteenth and Alameda streets. At the temporary warehouse forty cars of material have been housed, and nineteen cars of additional apparatus are now in the yards waiting to be unloaded, with thirty or forty more cars en route from Schenectady. Additional cars are being shipped from the company's factories, so that the stock at San Francisco will soon be complete. At present the company is in excellent condition to fill orders as rapidly as before the fire.

For the equipment of their new rolling stock, made necessary by the recent fire, the United Railroads of San Francisco have placed large orders with the General Electric Company, of Schenectady, N. Y., for various types of equipments. These include twenty-five 4-motor, 40-H. P. equipments; fifteen 4-motor, 50-H. P. equipments, and ten 4-motor, 75-H. P. equipments. All these equipments will be supplied with the flexible Sprague-General Electric system of multiple-unit control. The G. E.-80 (40 H. P.) motor is being widely used in railway work, many other companies having adopted it. It is the most suitable size for city work, and the special M. C. B. oil bearing design has proved extremely popular. The United Traction Company, of Albany, N. Y., has recently ordered twenty-five 4-motor equipments of this type, and the Philadelphia Rapid Transit Company, 100 4-motor equipments. In several instances the G. E.-80 motor is being substituted on cars already using a less efficient motor. Thirty-six equipments of four motors each were recently ordered by the St. Louis Railway Company, supplanting motors of another type.

The Dean Brothers Steam Pump Works, of Indianapolis, Ind., are installing electric motors for driving their machine tools and cranes.

The Lackawanna Steel Company, of West Seneca, N. Y., which recently decided to operate the greater part of its mills by electricity, and contracted for electric power with the Ontario Power Transmission plant at Niagara Falls, is now installing the electrical machinery in its power house at West Seneca. This machinery will include seven 1500 horse-power transformers and a number of motor-generator sets, which will transmit the power and make it available in the mills. These electrical improvements to the steel plant will involve the expenditure of several hundred thousand dollars, and, when completed, will add considerably to the operative efficiency and the producing capacity of the works. All of the electrical machinery will be furnished by the Westinghouse Electric & Manufacturing Company, of Pittsburg.

Announcement has been made of the incorporation of the engineering firm of W. S. Barstow & Co., with offices at 56 Pine street, New York City, and in the Failing building, Portland, Ore. Mr. Barstow, who has in recent years been closely identified with transmission and lighting work on the Pacific coast, has now secured the co-operation in the new company of J. B. Taylor, late with Westinghouse, Church, Kerr & Co., and R. L. Donald, late with the Southern Pacific Railroad. They will undertake the complete designing and construction of electric lighting, railway and power plants, and distributing systems, the designing and construction of industrial plants, the supervision and management of electrical properties, and special reports and examinations on operation, improvement and extension of existing installations. Very recently orders were booked for seven important installations running into millions of dollars. Mr. Barstow, who was at one time prominent in the electric lighting field, and manager of the Edison system in Brooklyn, is at present the president of the New York Electrical Society.

The Stanley-G. I. Electric Manufacturing Company's San Francisco office, which was until recently occupying temporary quarters in the Blake block, Oakland, has moved to the Atlas building, San Francisco.

The Franklin Electric Co., Franklin, Pa., has recently decided to increase their gas power lighting plant, and has accordingly placed with the Westinghouse Machine Company, of East Pittsburg, an order for a 125 H. P., three-cylinder, vertical-type gas engine. The company has operated a gas engine plant for several years, and has done away entirely with the use of steam. The present plant consists of five belted units of similar type, which have been giving uninterrupted service since the change over from steam to gas, and the present order is the outcome of the successful experience which the company has had with gas power. Natural gas is used in the plant, obtained from local wells, and is exceedingly rich, both the gas and oil occurring in this district being the richest known in any part of the country.

The Westinghouse Machine Company, of East Pittsburg, Pa., has recently received an order from the Portsmouth Street Railway & Lighting Company to install in their plant at Portsmouth, Ohio, a 500-KW. turbine. The turbine is to be of the multiple-expansion, parallel-flow type, and direct connected to a 500-KW., 60-cycle, two-phase, 220-volt Westinghouse generator. Two 400-KW. Westinghouse-Parsons turbines are already operating at this plant, serving the entire city with light and power. The plant was built entirely for turbine machinery. Superheated steam and high vacuum are used. Steam turbines of the same make as those installed at Portsmouth have been adopted by the Durham Traction Company, of Durham, N. C., and the Columbia Electric Street Railway Company, of Columbia, S. C., for traction service.

The San Francisco offices of the Fort Wayne Electric Works, of Fort Wayne, Ind., are temporarily at 67 Blake block, Oakland, Cal. The permanent offices will be in the Atlas building, San Francisco, as soon as the building is ready for occupancy. The company's stock destroyed by fire has been replaced.

Application for a charter has been made to the Pennsylvania State authorities by the Westinghouse Consolidated Foundries Company, of Pittsburg, Pa. The object is for the various Westinghouse Companies, which now have foundries at Pittsburg, Allegheny City, Cleveland and Attica, N. Y., to have all their castings made in one factory, which is located at Trafford City, near Pittsburg. This plan is to assure greater economy and uniformity in the making of foundry products.

Plans for the new works of the Arthur Koppel Company, of New York, and Berlin, Germany, have been completed by the engineers, Dodge & Day, of Philadelphia. Construction work will be started at once, and the plans contemplate the immediate building of a section of the erection shop, the light car shop, the switch shop, service building and office building, and a part of the power plant. The works are situated at Homewood, a place about thirty-five miles from Pittsburg, and will turn out many of the products which have hitherto been imported by the Arthur Koppel Company from Germany.

Kohler Brothers, of Chicago, through their Pacific coast managers, Abner Doble Company, have just finished installing a 4-motor Kohler equipment for the new octuple Hoe press, which the San Francisco "Examiner" has installed and placed in operation in its temporary building in San Francisco. They have also closed a contract for a 2-motor Kohler equipment for a sextuple Hoe press, which is now being shipped for the San Francisco "Call" for installation in its old building at Third and Market streets.

The American Axle Works, of Philadelphia, have found that the demand for their product greatly exceeds their present output. They have engaged Dodge & Day, engineers, of Philadelphia, to investigate the condition of their plant, and report on just what changes should be made to their present layout and what additional building should be undertaken to enable them to increase their capacity about 50 per cent.

Generators supplying current at 18,000 volts are to be installed in a new power plant at Redondo, a suburb of Los Angeles, Cal. The machines were built by the General Electric Company, of Schenectady, N. Y.

G. M. Gest, subway contractor, of New York and Cincinnati, has closed a contract, through the New York office, for the construction of 500,000 feet of conduit for the Toronto Railway Company, at Toronto. This will complete the subway system for that company, and will give it one of the most complete underground conduit systems of any railroad.

Following the recent starting of the 5500-KW. Allis-Chalmers steam turbine and generator unit at the Williamsburg power house of the Brooklyn Rapid Transit Company, Allis-Chalmers turbines have been put practically in readiness for starting at the power houses of the New York Edison Company, Bronx station, New York City; Westchester Lighting Company, New Rochelle, N. Y.; Dayton Lighting Company, Dayton, Ohio, and the Brooklyn Edison Company, New York. A 1500-KW. unit for the Memphis Consolidated Gas & Electric Company of Memphis, Tenn., having just undergone satisfactory test at the West Allis, Milwaukee, works, is now being prepared for shipment. Similar tests on three 500-KW. units, two for the city of Jacksonville, Fla., and one for the Western United Gas & Electric Company, of Aurora, Ill., will follow as rapidly as possible, after which the three 1500-KW. units ordered by John I. Beggs, to meet very unusual running conditions, will be rapidly brought to completon. These latter units are for installation in the handsome new station of the Milwaukee Electric Railway & Light Company, Milwaukee. The construction of steam turbines by the Allis-Chalmers Company, which has up to the present time been seriously handicapped for want of necessary space and working facilities, will very soon be transferred to the new turbine shop in unit No. 4, of the West Allis works, which is rapidly nearing completion and which will be devoted entirely to the construction of this type of prime mover.

A cyanide gold mill, with a capacity of 500 tons a day, is reported sold by Fairbanks, Morse & Co., of Chicago. The entire plant will be operated by Fairbanks-Morse direct-current dynamos and motors, driven by water power, a 240-foot head of water being available. The mill will be near Boulder, Col., and will contain many features of noveltv and interest. It will be a very modern and complete plant in every way.

The De La Vergne Machine Commany, of New York, are installing a 150-H. P. Koerting gas engine at the works of the Penn Hardware Company, of Reading, Pa. The engine is to run on producer gas.

The Canadian Westinghouse Company, Ltd., are doing a large business in steam turbo-generator equipments. The Northern Electric & Manufacturing Company, of Montreal, duplicated an order recently for a 300 -KW. Westinghouse-Parsons turbo-generator unit, to be installed in their power house alongside of one of the same capacity now in service. The generator is a 220-volt, three-phase, 60-cycle machine, operating at 3600 revolutions per minute, and will be of the latest enclosed type, while the turbine will operate at 150 pounds steam pressure with 100 degrees superheat. A turbine at present in service is operating part of the year condensing and through the winter non-condensing, the exhaust steam being used during the winter for heating purposes. It was the splendid operation of this steam turbine generating unit which led the company to order the one about to be installed.

New Catalogues

The Electric Storage Battery Company, of Philadelphia, Pa., have issued a new bulletin, devoted to the application of storage batteries to lighting and power plants. The installations of chloride accumulators furnished by this company for private residences in Groton, Conn., in Merion, Pa., and in Narberth, Pa., are illustrated and described. Similar installations have been provided by them for over 200 residential plants.

"Mechanical Firing" is the title of a publication recently sent out by the Ross Engineering Company, of New York. The object of this booklet is not to answer the question "Shall we put in mechanical stokers, or fire by hand?" but rather, "What mechanical stoker shall we put in?" The arguments presented are intended to show that the Ross mechanical stoker is the proper device to install.

The Phosphor-Bronze Smelting Company, Ltd., of Philadelphia, Pa., have issued a new price list of phosphor-bronze sheet, plates, wire, rods, wire ropes, ingots, castings, and anti-friction metal. Phosphor-bronze spring sheet is used as a substitute for German silver and brass in electrical apparatus, the wire for telegraph and telephone wires, the rods for the piston rods and valve stems of steam pumps, the ropes for rigging, transmission, hoisting and tiller purposes, the ingots and castings for parts of machinery subject to constant vibrations, and the anti-friction metal in place of Babbitt metal for heavy pressure and high speed.

"Mine and Quarry," a quarterly bulletin issued by the Sullivan Machinery Company, of Chicago, Ill., recently made its first appearance. Electric rock drills built by this company, it will be remembered, were illustrated and described in the June issue of The Electrical Age. The pamphlet contains illustrated articles on rock excavation at Panama, modern methods at an Illinois mine, diamond drilling, power extension of the Chicago drainage canal, low cost of compressing air for drills, cleaning granite by compressed air, and suggestions for the operation of rock drills.

The Cooper Hewitt Electric Company, of New York, recently sent out several publications, one illustrating and describing their indoor type of mercury vapour lamp for direct-current circuits, another treating in a similar manner their indoor type of mercury vapour lamp for alternating-current circuits, and a third dealing with the applications of these lamps to general industrial purposes.

"The New Surface Car of the Brooklyn Rapid Transit Company" is the title of an attractive booklet, illustrating and describing this new type of surface car, and giving the reasons for its adoption. The new car embodies a number of improvements over those previously used, among which are increased accommodation, greater comfort to passengers, increased ability to maintain schedule time on city and suburban lines in all kinds of weather, a satisfactory winter and summer car, and reduced liability to accidents.

The Robins Conveying Belt Company, of New York, illustrate and describe in a new bulletin their conveying and elevating machinery for retail coal pockets and locomotive coaling stations. The belt, idlers, take-up bearings, pillow blocks, distributing trippers, and brushes, are each described in detail. Illustrations are given showing retail coal pockets and locomotive coaling stations in different parts of the country where the Robins conveying and elevating machinery is used.

Motor-driven laboratory lathes for the light polishing and grinding done by dentists and jewelers are well illustrated in a new bulletin issued by the Emerson Electric Manufacturing Company, of St. Louis, Mo. The lathes treated of in this bulletin are driven by 1/10-H. P., 110 or 220-volt direct-current motors, and operate at three speeds,—1500, 2220, and 3000 revolutions per minute. A set of eight chucks for dental work, a bristle polishing wheel, and a grinding wheel, accompany the lathe.

The Allis-Chalmers Company, of Milwaukee, Wis., have recently sent out two new publications,—one a bulletin relating to their steam turbines and generators, and the other a folder containing a reprint from the Milwaukee "Sentinel" entitled, "The Rise of a Great Company." The bulletin gives an elementary description of the Parsons type of steam turbine built by the Allis-Chalmers Company, and is accompanied by a number of well-selected illustrations showing its construction.

"Kinks" is the expressive title of a 70-page booklet issued by the National Carbon Company, of Cleveland, Ohio. This is the third edition of the booklet, which contains much valuable information for those who own or operate automobiles or auto-boats. One of the main features discussed is the ignition system, and for this work the "Reserve" dry cell is recommended. This cell is made by the National Carbon Company in three sizes:—2½ by 6 inches, 3 by 7 inches, and 3½ by 8 inches.

A monthly record book for managers and operators of electric light and power plants and gas works has been sent out by the Gas & Electric Development Company, of Philadelphia, Pa. This company has been organized to act as broker or agent in the purchase and sale of public service properties, such as electric light and power plants, gas plants, waterworks, and electric railways. Also, to act as consulting engineers in connection with the construction and operation of such properties, and to undertake the operation, supervision, or management of them under special agreement as to results and compensation. The book is well gotten up, and may be had on application to the company.

The Gisholt Machine Company, of Madison, Wis., have issued a new leaflet describing the use of Gisholt lathes in finishing armature spiders. The process is divided into two operations, which are described in connection with two illustrations showing the spider in the lathe.

Steel trucks for factories, foundries, and shops are well illustrated in a 35-page catalogue recently sent out by the Lyon Metallic Manufacturing Company, of Chicago, Ill. A number of different styles of trucks are shown to give an idea of their uses, and in each case the standard dimensions, capacity, colour, and price are given.

The De La Vergne Machine Company, of New York, has just issued a new 82-page catalogue, describing the mode of operation of the "Hornsby-Akroyd" oil engine, and giving illustrations and short descriptions of the more recent installations of these engines. More than 14,000 of these engines are now in operation. It is claimed that the cost of power developed by them is from one-fourth to one-half cent per B. H. P.-hour.

In a catalogue recently issued by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, electric hoists are illustrated and described. The various types include single and double-drum hoists fitted with alternating-current motors, single and double-drum hoists fitted with direct-current motors, hoists with reels, electrically operated water hoists, and various special types.

The Metropolitan Engineering Company, of New York, have sent out a folder, announcing they have lately placed on the market a new electric sign letter, which is imperishable. The letter is made of sheet steel, pressed in the desired shape. Socket holes are then punched in it, and the letter is given a heavy coat of porcelain enamel in any desired colour.

Taplets, attachment plugs, and rosettes made by the H. T. Paiste Company, of Philadelphia, Pa., are dealt with in a new bulletin. The different styles of these products are well illustrated, and instructions are included regarding the purposes for which they are intended, together with the reasons why they should be used.

Personal

H. C. Baker, formerly in charge of the Atlanta, Ga., office of the Crocker-Wheeler Company, of Ampere, N. J., in which capacity he became favourably known as an electrical engineer throughout the Southern industrial field, has started for San Francisco, where he will take charge of the Pacific coast territory of the Crocker-Wheeler Company. The offices at Fremont and Howard streets, San Francisco, were completely destroyed by the recent fire; temporary offices have been established at 2611 Broadway. Mr. Baker will enter an active field of electrical development in which the company is already conspicuously established by its installation of 4000-KW., alternating-current generators in the plant of the California Gas & Electrical Corporation. These machines, the largest gas-engine-driven alternators in the world, escaped damage in the recent disaster.

Professor David S. Jacobus, who for twenty-two years has been on the faculty of the Stevens Institute of Technology, at Hoboken, during the last ten years of which period he occupied the chair of experimental mechanics, has resigned, to become associated with the Babcock & Wilcox Company, makers of the Babcock & Wilcox water-tube boiler, of New York. Professor Jacobus' resignation took effect with the end of the college year, and the Institute, in appreciation of his services to engineering science, conferred upon him the honorary degree of Doctor of Engineering, making him one of a small, distinguished company composed, among others, of Dr. E. D. Leavitt, Jr., Coleman Sellers, Francis B. Stevens, and Rear-Admiral George W. Melville, U. S. N. To Professor Jacobus' many friends and acquaintances, his severance from the Institute will, no doubt, be a matter of surprise. The Babcock & Wilcox Company is to be congratulated upon having acquired his services.

Cabot Stevens, for many years electrical engineer of the Edison Electric Illuminating Company, of Brooklyn, severed his connection with that company on June 1, to accept a responsible position with Stone & Webster, of Boston. His first work will be at Columbus, Ga., where he will represent Stone & Webster in the construction and operation of a large light, power and railroad plant.

At a meeting of the Council of the American Society of Mechanical Engineers, held June 6, it was unanimously decided to invite Calvin W. Rice, at present a consulting engineer of the General Electric Company, in New York City, to become secretary of the society. The position will be made vacant next December, at which time the resignation of Prof. F. R. Hutton, announced in a previous issue, will take effect. Mr. Rice has been a very active member of the society, and is now chairman of the committee on papers. While he still has the offer under consideration and has not yet positively accepted it, it is confidently believed that he has the society's welfare so much at heart that he will be willing to make the sacrifices necessary if he devotes himself to this new work.

N. A. Christensen, the inventor of the air brake and the air compressor which bear his name, is now with the Allis-Chalmers Company, of Milwaukee, Wis., who have purchased the exclusive rights to manufacture and sell them. One of the company's shops is now being fitted up for turning out this equipment. Mr. Christension is a Dane, and came to the United States in 1891. After the invention of his air brake, the Christensen Engineering Company was formed to manufacture it, and was subsequently merged in the National Electric Company. In the spring of 1905, the latter company went into the hands of a receiver and was sold at public auction to interests representing the Westinghouse Air Brake Company, which legally surrendered all rights, title and interest to all the Christensen patented devices, and also settled the claims of Mr. Christensen against the National Electric

N. A. CHRISTENSEN

Company and its receiver. Since this settlement, negotiations have been brought to a successful issue with Mr. Christensen for the consolidation of the Christensen air brake and compressor business with the interests of the Allis-Chalmers Company, Mr. Christensen himself going to this company as consulting engineer.

At the celebration of the seventy-fifth anniversary of the Koeniglich Preussische Technische Hochschule, of Hanover, Germany, one of the most prominent scientific institutions in the world, the honorary degree of Doctor of Engineering was conferred on Mr. Ernst Koerting, the noted European engineer, of the well-known firm of Gebr. Koerting, A. G. Koertingsdorf, Hanover, for his scientific researches and discoveries in gas engines and other important branches of engineering. Dr. Koerting lives in Pegli, Italy. He is interested in a number of large enterprises in the United States, among them the De La Vergne Machine Company, of New York, as well as the Schutte-Koerting Company, of Philadelphia, and is at present visiting this country.

Walter Robbins, assistant to the manager of the apparatus department of the Western Electric Company, of Chicago, has resigned his position with that company, and will on July 1 assume the duties of assistant to the manager of the Wagner Electric Manufacturing Company, of St. Louis.

H. M. Hirschberg, president of the Excello Arc Lamp Company, of New York, left that city on June 15, on the steamer "Celtic," for a flying visit abroad to the factories of both "Excello" lamps and carbons, to complete arrangements for prompt deliveries next season.

Frank George Baum, recently elected a vice-president of the American Institute of Electrical Engineers, was graduated from Leland Stanford Jr. University in 1898, in the department of electrical engineering, which was at that time under the direction of Dr. F. A. C. Perrine. In addition to completing the full quota of university work in the specified time, he managed to do considerable outside work as a means of paying his way through college. In view of his success as a laboratory experimentalist, he was placed in charge of the electrical laboratory in the Summer school during the later portions of his college course, and, after graduation, was appointed instructor in electrical engineering, being later advanced to the rank of assistant professor. While carrying on his work at the university as an instructor, he managed to do considerable work, especially during the summer vacation, as consulting engineer for various power companies in San Francisco, Los Angeles and elsewhere. So successful was he in this field that he received a very flattering offer from the California Gas & Electric Corporation to take charge of the electrical engineering of their great system, which centres in San Francisco. He occupies the position of electrical engineer and superintendent of transmission for this company at the present time. Mr. Baum's mathematical powers were exhibited not only in his work as a student, but also more particularly in his ability to apply mathematics to solving practical problems. He presented the first thoroughly satisfactory solution of the capacity of a multiphase line, and experimentally proved his conclusions (A. I. E. E. Transactions, Vol. XVII., 1900, page 345). While at Leland Stanford, he solved the problem of voltage control for the Bay Counties Company, at Oakland, by compounding the synchronous motors with the railway current. At Los Angeles, also, he solved the problem of the interference of long-distance lines with telegraph lines. In 1902 he published a calculating device for alternating-current circuits, employing a new graphic diagram. He has also published a book on transformer calculations.

F. G. BAUM

A. M. Schoen, recently elected a manager of the American Institute of Electrical Engineers, is chief electrician and engineer of the South-Eastern Tariff Association. He was born in Richmond, Va. In 1889 he received the degree of Civil Engineer from the Virginia Military Institute, and engaged in railroad and bridge construction during the two years next ensuing. He was afterward engaged in electrical work in Richmond, going later with the Thomson-Houston Company, at Lynn, Mass. After remaining with them until the formation of the General Electric Company, he returned South and took up central station work in Virginia and Georgia. Prior to 1905 he took charge of the electrical inspection department of the South-Eastern Tariff Association, with jurisdiction over the eight States from Virginia to Louisiana. Mr. Schoen has been doing more or less consulting work in addition to his work for the association.

A. M. SCHOEN

How to Make a Small Electric Plant Pay

By D. F. McGEE

From a Paper Read at the Atlantic City Convention of the National Electric Light Association

HOW to make our electrical properties earn a dividend for their stockholders is a subject that is engaging the attention of the brightest minds of the country. The author of this sketch undertakes the task with fear and trembling, but, believing it to be the duty of every central station manager to contribute his mite toward hastening the solution of this very important problem, he has responded to the request of our president to furnish to this association a paper describing the methods which we adopted to transform into a dividend-earned an electrical property, operating in a town of five thousand population, that had previously been a losing investment.

It has been proved that an entirely modern equipment is not essential for the financial success of an electric plant, and a wise manager of a small plant will hesitate before he consigns to the scrap heap equipment that he might, by overhauling and judicious arrangement, be able to operate at a net efficiency equal to the most modern equipment, besides saving for his company the amount required for new equipment and increased fixed charges that must necessarily follow such an expenditure. On the other hand, if he finds that his requirements and conditions call for an entirely new installation, he should not hesitate to make it, provided he can get the funds to do so—which is often difficult in a small plant.

The boiler room is usually the most neglected part of the small plant equipment. Uncovered pipes, leaky valves and joints, improper boiler setting, careless firing and injudicious selection of fuel, are a few of the dividend-consuming devices common to small plants. It is well to have as few different sizes of valves, fittings, etc., as possible in the piping equipments. By making the nipples and short pieces of pipe of some uniform length, repairs will be simplified, and many a shut-down be prevented, and a much smaller stock of fittings will provide for emergencies.

Boilers should be inspected at regular intervals and kept free from scale. Scale in boilers is often the cause of enormous waste of fuel. Every steam plant should have recording thermometers installed in the feed-water lines to boilers. The average engineer in the small plant does not realize the necessity of heating boiler feed water to, at least, 200 degrees.

Many central-station managers would have a rude awakening if they would take the trouble to install recording instruments. Recording voltmeters, as well as thermometers, will provide a healthy incentive for your men to attend to their duties, and will also provide a means by which that mystery of voltage variation, which has given us all so much trouble at various times, may be solved. It is well known that one of the chief difficulties in small plants is to have competent help available when accidents or other trouble occur, which is generally during the time of the heaviest loads. We have provided for this by dividing the power-house force into three watches, with the understanding that they are to work 10 hours per day. This provides double force on duty 2 hours each day to make all repairs and tide over the peak-load period.

Engines should be indicated regularly, and valves adjusted for the most economical steam consumption. Tests of water and fuel consumption should be made at stated periods. A log book should be kept, showing records of the hourly readings of the various instruments. Daily readings should be made of the switchboard wattmeters. No plant is too small for those instruments. If a plant can not afford load-curve drawing instruments, the engineer or switchboard attendant should plot the daily load from the ammeter readings. The curve thus drawn will bring before you plainly that hollow place in your load line that must be filled before you can corral that dividend-earning germ which we are all striving to cultivate with more or less success.

The distributing system of a small plant is very often the source of considerable waste. The annual losses from poor line construction, inefficient transformers and badly-designed feeder systems, would go a long way toward paying dividends. The line and transformer losses on above-mentioned plant at present are only 60 per cent. of what they were five years ago, when the income was only 25 per cent. of the present earnings. We scrapped thirty transformers and replaced the entire lot with four large ones, using three-wire secondary network with banked transformers to take care of this large increase in business.

The first duty of every manager is to provide for reliable and continuous service. He must furnish "the goods." Excuses won't go with the up-to-date American citizen.

His next duty is to his company. He must see that it receives an equitable return for money invested by it to provide the equipment to supply this service. Before he can do this, he must first know, beyond question, what constitutes the various costs that go to make up the entire operating expenses of the plant. He must be able to make a monthly comparison of his various costs, for it is only by this means that he will be able to keep a check on his operating expenses. By studying carefully all the facts and factors that constitute his costs, the manager will be able to steer clear of the folly of taking on unprofitable business.

In plants located in cities with populations of ten thousand and less, the manager must be familiar with every detail of his business. He must be his own solicitor. It has been said that an outside man can interest and get customers that the local manager cannot reach. If he can, it is because he is a man better fitted for the business. The manager of a small plant should know ways and means of approaching a prospective customer that a stranger cannot know. He should study the ambitions and weaknesses of every prospective customer. Often it is the wife and mother that should be approached, perhaps in an indirect manner. Very often it is the daughters of the house who aspire to have as many conveniences as their neighbours. A hint from any source should not be neglected. There is always some way to land an interested party. A manager is not worthy of the name if he cannot find a way to do this.

Above all, a solicitor must be specific, and must be thoroughly posted regarding cost of installation and cost of operating the article sold; also regarding its maintenance. He must be able to say, "Buy this; it will cost you so much to install and run, and will give you so much profit." He must be able to meet any argument that may be advanced by his competitors. Above all, he must be truthful. He must not make rash promises. It is well always to allow a factor of safety in this respect. How gratifying it is to hear from a customer that he is getting better results than you promised him. The writer can recall one incident that has afforded me considerable pleasure, as well as profit. A German owned a blacksmith shop in our little city. After a lot of hard talking, a small motor was installed to operate his tools. Some time after, the writer called on him and enquired how he liked his power. He replied, "One boy put that thing in here, but it would take several good men to get it out again." As he is a very profane man, he used much more forcible language to express himself on this subject. The writer used this story many times since, and must say that it has helped to close up the sale of a good many motors.

The manager of a small plant must keep posted regarding the latest and most efficient types of different apparatus, lamps, reflectors and so forth. He should read all the trade publications; not only the reading matter, but should study the advertisements as well. He will miss a great deal of valuable information if he does not. He will often find the solution in those pages of some difficult problem that has bothered him for months. Many manufacturing concerns gladly furnish binders for their literature. This matter, when properly assorted, represents a mass of valuable information that can be acquired in no other manner, so there is no excuse, save "that tired feeling," for a central-station manager not being up to date.

It is somewhat difficult to convince a customer that if his requirements call for a 25-H. P. motor, he would only have to pay for 5 to 10 H. P. A very large proportion of the load that can be secured by a small plant is intermittent. The customer averages a payment for only about 25 per cent. of his actual installation. By carefully studying the requirements of all prospective customers and familiarizing yourself with their actual costs, you are then in a position to go to any one of those customers with a proposition that will save them money. If you can show the average man that you can cut down his expenses or decrease his manufacturing costs, you will have no difficulty in getting his business.

One of the most desirable classes of customers is the small refrigerating plant; especially when they install brine cold-storage tanks. Arrangements can be made with this class of customers to shut down their motor during peak loads. The cost of this class of power would be only the net additional cost of fuel and proportion of your general expense, as it does not increase the peak load on the station. A careful analysis of costs will work wonders toward helping the manager of our small plants in building up that hollow of low business in daytime.

The manager must be able to plan the most efficient arrangements of machines. In very many cases, such as machine shops, grouping the machines will permit the most efficient operation. In other cases, such as printing plants, individual motor drive is preferable.

It pays to study every installation, giving your prospective customer your very best advice, for there is no advertisement so cheap and good as a satisfied customer. Above all, create confidence, for confidence is the foundation of new business. Pay every attention to the little things. The average user of power knows nothing at all about electricity or mechanics and cares less. What he wants is to see the wheels go round. Have your trouble man call at the various installations at stated intervals, making a report to you of any abuse or misuse of the equipments. The average patron will appreciate this. He can well afford to pay a small sum for this inspection to insure him against a shut-down.

One of the best means to increase your business is to co-operate with architects and builders. The advice of a disinterested party will go a long way with the houseowner.

Be prompt in looking after trouble. Let your customers know that their troubles are yours. Make yourself and your service indispensable to them; keep posted in regard to the troubles of users of other sources of power. We have often taken advantage of a breakdown in both steam and gasoline engines to install a motor to help them out of a difficulty, and we have never had occasion to take the motor out afterwards, as the engine would invariably pass to the second-hand man.

With all due respect to advertising, it must not be thought, however, that the getting of new business, in a small city, is dependent on advertising alone. There must be good and reliable service as a foundation for all this. The service must be continuous and free from interruption. Voltage must be steady. With such good voltage regulators on the market, there is no excuse for poor regulation. Customers' installations must be looked after by the central-station manager to insure their being maintained in good condition. He must watch the little things, keep dim or other inefficient lamps weeded out. At an early date we adopted a liberal policy regarding free lamp renewals. It is also essential to have a schedule of rates that will attract the long-hour or all-day customers for both light and power.

You must educate the people away from the idea that electric light is for the well-to-do only, for the difference in the yearly cost for redecorating houses where electricity, gas or kerosene is used will often more than pay the entire electric light bill for the year. Where electric light alone is used, the redecorating cost is about one-half as much as it is where the other illuminants are used.

Regarding advertising in local papers, it is very necessary to retain their good will, and some money can be spent in this manner to advantage.

A short time ago there was an epidemic of burglaries in our city. To one paper we furnished a news item, supposed to be an interview with a reformed burglar, stating that he always gave an electrically-lighted house a wide berth while he was in the business, because he never could tell when a light would be snapped on him from an upper story.

To another paper we furnished a news item, to appear as a statement by a noted detective, advising people to have their houses wired so that the lights in the lower rooms could be switched on from an upper story. We were indebted to an electrical trade paper for this hint. We believe that we received more benefit from this one item in one issue of two newspapers than we should have received from a bona fide advertisement running a year in the same papers. The idea is to take advantage of the psychological moment to instil your proposition into the minds of your prospective customers.

Advertising novelties are of questionable value to small plants. Every manager finds upon his desk every morning a mass of advertising matter, which he immediately confines to the waste basket. There may be valuable matter hidden somewhere in this mass. The average manager has too many duties that demand his attention to waste it in wading through so much trash to discover them. Every business man has similar experience. We have found that the better way is to install a number of the articles, the sale of which we desired to push, in a number of carefully selected places, where they will be seen and talked about; and this, after all, is the only result to be gained by advertising. It is then up to the manager or his solicitor to strike while the iron is hot.

The largest casting ever poured at the West Allis works of the Allis-Chalmers Company was a 90-ton bedplate, recently cast for a rolling-mill engine now being built for the Carnegie Steel Company.

THE ELECTRICAL AGE

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The Electrical Age Co.
New York and London

The Neglected End of the Power Station

By H. T. HARTMAN, of the Electric Company of America

WHICH of the various complicated and closely related parts of a central station will best repay careful study? Where is money being wasted? Where is apparatus most abused? Where is more intelligence most required? These are some of the vital questions coming up in the operation of a power station.

Most stations have switchboards that are fairly safe and convenient, both for operation and repairs. The wiring is usually well and safely installed. There is comparatively little to be looked for in the matter of efficiency of dynamos, that of even the smallest in commercial use being only little less than that of the larger sizes. A wonderful advance has been made in the efficiency of engines during the past few years, and the construction of the leading makes leaves little to be desired.

The engine room personnel is usually of a high class, well paid, intelligent, ambitious and reliable. The average engine room is clean and well cared for, and general attention is focussed on its operations. The records are carefully kept and the necessary repairs promptly and thoroughly attended to. In short, the engine room is the model part of the station.

What an uninviting contrast the boiler room generally presents! The windows are few in number and poorly located; the glass is covered with an accumulation of grime of a thickness depending on the age of the station. The walls, roof and floor are black with soot, oil and dirt; all the otherwise vacant spaces are occupied with pieces of pipe, rusty pipe fittings, old tools and the miscellaneous junk that goes to make up the power plant scrap heap. The boiler walls are cracked, the pipes and pumps leak, and the pipe covering hangs in festoons, looking as unkempt and forsaken as is possible in any inanimate object. The rough, uneven brick floor is covered with coal in front of the boilers, and the general air of the place is that of slovenly, dirty incompetence.

The writer does not mean to say that all boiler rooms answer to this description. There are plenty of notable exceptions, but it is true of a sufficiently large proportion to make it only too familiar.

There are several reasons for this really distressing state of affairs. We do not have to seek far for one of the most prominent. It wears dirty overalls and draws the munificent salary of 14 cents per hour, and works twelve hours per day and 365 days per year. Any one who is fit for nothing else on the face of the living earth is generally considered to be quite good enough for a fireman.

He is naturally looked down upon, and if he has any ambition in the line of station work it is to get out of the fireroom into the pleasanter and more remunerative branch of the business. No engineer likes to take a shift in the boiler room even in case of emergency, and such a thing as having to help in unloading a car of coal is looked upon as little short of a disgrace.

Yet upon the fireman devolves the handling and combustion of coal costing an amount from six to ten times his daily wages. The apparatus he cares for costs almost as much as the carefully cherished engine room outfit, and in no place about the station is there more imminent probability of a destructive accident, due to only a slight degree of carelessness, ignorance or neglect.

Now what are we to do to remedy this state of affairs, and will it pay to make the attempt? Answering the last question first, the writer would say that in his experience there is no other place about the station where a little trouble and a little expense will meet with such immediate and gratifying returns.

When the fireman wheels his own coal, the cost of boiler room labour with hand-fired boilers runs from 30 to 40 cents per ton of coal, so that there is frequently room for saving in the cost of labour, even in a station where a conveyor system would be out of the question. The greater part of the time which might be saved is occupied in unloading cars or in getting the coal into the boiler room, or in handling ashes.

Frequently the siding is so arranged that the average distance the coal must be hauled is too great. Sometimes it must be wheeled uphill. In many cases an industrial railway can be installed at small initial cost that will work wonders in the direction of eliminating the heavy work that leaves the fireman too little energy for the vital part of his job. Sometimes a change in the siding will be of the very greatest benefit.

There is a class of stations comprising a very considerable proportion of the total investment in such properties, where the coal consumption is too great for hand wheeling and yet not large enough to justify the installation of a conveyor. In such cases a mule and cart will fill a long-felt want.

But this is a small matter beside the possible saving in fuel. The writer has known of instances where there was a difference of as much as 40 per cent. in the amount of fuel burned by different firemen in the same station, using precisely the same equipment and fuel, and operating the same load.

In the matter of repairs there is no place about the station where the traditional "stitch in time" is so sure to save big bills. At the same time, there is no place where the forces of destruction are so insidious and give so little warning of impending trouble. Unceasing, unwearying vigilance is the only way to avoid it.

As the theoretical heat values in bituminous coals vary as much as 40 per cent., and as the commercial difference is sometimes even greater, it is apparent that the price is not always the best criterion. The fact that the best and poorest coals frequently pay the same freight rate, which is often 40 per cent. or more in excess of the cost of the coal itself, forms an additional and very important reason why the central station should decide the really momentous question of the choice of fuel only after careful experiment under actual working conditions, taking into consideration all the items that make up the boiler room expense account in determining the comparative cost per kilowatt-hour of the various coals under test. Any test of twelve or even twenty-four hours is almost sure to be misleading, for the following reasons:

First.—Such tests are generally conducted under a fixed load, which is not true of the every-day commercial conditions.

Second.—The state of the fire at the beginning and end of the test may account for too large a percentage of the total coal consumed.

Third.—The firemen are more or less keyed up by the fact that a test is on and that their superior officers are present.

Fourth.—Each kind of coal has peculiarities of its own that require close observation and test to obtain the best results. For example, a man accustomed to firing a very volatile coal would fire a good coking coal very uneconomically until he learned the knack.

The most obvious and cheapest reform in the boiler room is a general house-cleaning. Wash the windows you have, and add others if this does not give floods of light. Put the new windows where they illuminate the dingy passage back of the boilers and show up all the grime on the pumps and heater. One can hardly expect the fireman to care much about the cleanliness of his department or about his own personal appearance if the results of his work are not apparent. Scrape the walls and inside of the roof, and put on a good coat of whitewash. See that there are plenty of incandescent or arc lights conveniently placed, so that the boiler room is at least safe to walk around in at night.

There should be a ventilator in the boiler room roof to make the temperature supportable in the summer time, and there should be a porcelain-lined iron sink with hot and cold water and a connection to the sewer for the waste water. There should be closets for the men to store their clothes in. Whether or not it is true that "cleanliness is next to Godliness," it certainly has an important bearing on self-respect, and without this quality in the firemen, the best of apparatus will show poor results.

The question of hours of work and rates of pay is a delicate one that each station must settle for itself. It is quite evident, however, that a desirable class of men for such arduous and important work as that of firing and attending to boilers is not likely to be attracted to a job requiring twelve hours work a day and seven days a week for wages no greater than are offered for safer, lighter and more agreeable work that affords a day off each week.

The experience of the writer is that much better results are obtained by taking on young men with no previous knowledge of the business and breaking them in to the work. It is hard to get the older men out of slipshod and wrong methods that they have learned at other plants. There is no one so positive or so set in his ways as an ignorant man who has grown up in a business that he has not even half learned, and any attempt to change existing methods will instantly meet with his opposition.

With the green hand, experiments can be made with a given coal until the best method of handling it and firing it is arrived at, and he will then continue on the right path, provided there is a reasonable amount of supervision.

After all, the vital point is economy in coal, and in the following the writer has undertaken to indicate a few of the more important matters to which constant attention must be directed if good results are to be achieved.

Iron is a good conductor of heat; all scale-making materials are poor conductors, and high efficiency cannot be obtained unless the boiler is kept clean. An analysis of the feed water should be obtained from some independent chemist, or from one of the prominent boiler insurance companies that maintain laboratories for the purpose. They will not only furnish the analysis, but will also prescribe for any given case. Do not ask for an analysis from any one who has a boiler compound to sell, for you will probably get no information that will be of real use to you.

Many of the boiler compounds on the market are very injurious to a boiler, and unfortunately the results are not always apparent until the damage has reached a dangerous point. The best of them generally consist mainly of soda ash, which can be bought in the open market for about one-fourth of the cost of the compound. Common building lime or quick lime is another prominent ingredient. Both of these are good, but neither should be used except in such proportions as may be prescribed by a competent chemist for the water in question.

Kerosene or other light oils are often used as boiler compounds, but in the opinion of the writer it is better not to use oil except when cleaning the boiler. If all the water is drained off and the oil applied to the scaled parts, it disintegrates the scale, and when the boiler is filled again and a slow fire applied, the scale breaks off, and the boiler should be carefully cleaned at once before it is put into service.

Of course the best way to keep a boiler clean is to purify the water before it reaches the boiler, but in many cases it is impracticable to even consider the several systems that are showing such good results in various parts of the country.

If a boiler compound be used, the only thing it can do is to either soften existing scale or throw down scale-making materials in the form of a soft precipitate. This material must be removed from the boiler either through the manhole or hand-hole plates or through the blow-off. Now, the blow-off is so much the most dangerous point about a station that one can only wonder at the light-hearted temerity — the almost criminal ignorance and neglect—with which it is treated.

It seems axiomatic to say that a blow-off should leave the boiler at its lowest point, yet this is frequently disregarded. Consequently it is impossible to blow out all the contents of the boiler, and the sludge that remains in it bakes fast to the shell as soon as the boiler is started. The blow-off should be so installed that it can not be put under strain if the boiler setting settles, and it should be protected from the direct action of the fire,—in the case of a tubular boiler by a sleeve of larger pipe, preferably connecting with the open air. A blow-off valve should be provided in addition to the usual cock so as to prevent leakage and so as to give an opportunity for repairs when necessary without shutting down.

With many kinds of boiler feed-water, a surface blow-off is of the very greatest advantage. But in any case every boiler in use should be blown down at least once a day and, with bad water, three or four times. Otherwise the sludge and flakes of scale will remain in the boiler and bake fast to the surfaces.

In blowing off, the pressure should be low,—not over 40 or 50 pounds, —and the cock should be wide open. Then the valve that is in series with it should be very gradually opened to its fullest extent. After the boiler has been blown down from one inch to a full gauge, depending on conditions, the valve should be very slowly closed again, and after it is tight, the cock should be closed, too. Unless the opening and closing of the valve is done very slowly, severe strains are set up, and unless the valve is wide open, particles of the scale may lodge in the blow-off pipe, with the ultimate result of burning it out. It is desirable that the boiler be allowed to stand for several hours before blowing off, so as to allow the particles to settle, but this is frequently impossible under electric lighting conditions.

The chief engineer should personally inspect the operation of blowing off. It is too generally neglected and entirely too important to justify its being trusted to any one else. The boiler must be cleaned at regular intervals depending on the character of the feed water. This is a job of such importance that the chief engineer should be present and satisfy himself by personal examination that it has been thoroughly done.

Assuming that the boiler is clean, the next point is to see that it is thoroughly tight. Cold air leaking in lowers the temperature and reduces the draught. Double boiler walls are a prolific source of leaks, and other danger points are where the iron framework of doors, etc., joins the brick work, and at the junction of the breeching with the setting. Cracks may be discovered by means of a lighted candle, but the safest way is to provide against them by painting the entire setting at periodical intervals with fire clay of about the consistency of cream. The spaces around the door framing, and other parts, should be calked with asbestos fibre or mineral wool.

Assuming that the foregoing points are carefully attended to, the next and most important thing is the firing of the coal. The main reasons for inefficiency in combustion are poor draught, due either to insufficient or poorly designed stack or breeching, or both; air leaks in or around the setting; insufficient grate surface; insufficient air space in the grate; methods of firing the coal.

The draught may be ascertained by means of a very simple gauge, and there should be one on every stack. Parenthetically it might be remarked that it is put there for daily examination and not for decorative purposes.

Rankine's formula for stack dimensions, the one usually followed, is based on the difference in weight between the air in the chimney and that of an equal volume of air outside. As this depends on the relative temperature, it is plain that every leak must exert a decidedly adverse effect.

Many kinds of coal burn to best advantage when consumed slowly. When forced, such coals clinker badly or flow in a sticky mass that chokes the draught. Other coals burn best when forced to high temperatures. Generally it is safest to provide ample grate area. One square foot of grate area to 45 square feet of heating surface is not too much. If this is attended to it is pretty certain to follow that there will be sufficient air space. The method of firing must be adapted to the coal. What would be good practice with one might not serve at all with another. The main points to attend to are as follows:—

1. The coal burns most freely near the side walls and bridge wall on account of the radiation of heat from these surfaces. Therefore, it is necessary to have the bed of coal thicker at these points than on the rest of the grate.

2. In the body of the grate the coal should be uniformly distributed. Do not allow hills and valleys to form or there will soon be a "hole in the fire" through which cold air passes to chill the hot fuel.

3. With coals having a high percentage of volatile matter, fire one side and allow it to become incandescent before firing the other side of the furnace. In this way the gases distilling from the green coal are ignited and consumed by the heat arising from the other side of the furnace.

4. With coking coals, drench with water before firing. A mound of green coal is left on the dead plate to coke. As soon as it is coked it is broken and pushed back evenly over the grate, taking care to bank up a little along the walls and across the bridge wall. Then the mound is renewed with green coal and the process repeated. This sounds ludicrously simple, but it takes judgment and experience, and no little strength and fortitude, as a coking fire is intensely hot.

5. It must be remembered that every time the fire doors are opened air rushes in to cool the fire and impose a heavy contraction strain on the iron work. Consequently they must be opened as seldom as possible and kept closed all the rest of the time. It is, however, of very decided advantage to open the peepholes in the fire doors after the green coal has been fired in and before it has thoroughly ignited.

It may be considered superfluous to mention the fact that all the coal used must be weighed. But in many, one might even say in most, cases the weighing is done in such a manner that, while it may constitute an accurate measure of the day's coal consumption, it is useless as a guide to the fireman.

What if he does know that in the pile of coal at his back there are forty tons of coal that will all be used up by morning? He may be firing his portion of that pile most inefficiently without the slightest conception of the fact. It is therefore better, where it is possible, to bring in the coal in small quantities to be weighed and used as received.

A very valuable habit to inculcate in firemen is that of counting the shovels-full used in a given period, and for this reason a good clock with large dial and conspicuous figures should be part of every boiler room equipment.

It does not do to depend absolutely on the scale for the weight of the coal used. Between dirt and wear there is considerable variation, and every scale should be checked at frequent and regular intervals.

Probably the most accurate method of determining efficiency of combustion is by analysis of flue gases. The apparatus is not expensive, and the process is one that any intelligent engineer would comprehend. The trouble about it is that by the time the analysis is made, the fireman is likely to have forgotten the precise conditions and appearance of the fire, and consequently the process of experiment is long and tedious. A continuous automatic recorder of the amount of CO_2 produced has recently been invented, and, if accurate, should prove a most valuable instrument.

It is the belief of the writer that to

arouse interest in coal economy among all concerned it is necessary to have some visual record of evaporation. Water meters are, unfortunately, inaccurate, especially when used with muddy water, which clogs the working parts. The readings have, however, some relative accuracy; that is, for the same pressure and volume of flow, the readings will be within a comparatively small percentage of each other.

In many respects the most satisfactory, and certainly the most accurate, method of measuring the water evaporated is by means of the familiar device of two barrels, one being filled as the other is emptied. By having floats with graduated gauges, the fireman can see exactly what is happening. This plan has also the very great advantage that it insures the presence in the boiler room of at least one or two of those "higher up." It arouses a general interest in the subject and a feeling of pride and emulation among the firemen that would make frequent experiments of this kind worth while if they had no other effect.

Another point the fireman must watch is the water level. If he does not keep this uniform he is working at poor efficiency. To avoid this he must pay attention to the load and keep his pumps working constantly at a speed that will maintain the water at the right height.

The fireman must strive to maintain the steam pressure constant. A recording gauge will help him to remember that his chief will know just how carefully he has been attending to business. In order to keep a good steam line he must attend carefully to the dampers and ash pit doors, anticipating the rise of the gauge needle. There is no possible excuse for a fireman in an electric light station allowing the safety valves to blow.

Finally, it will not do to tell the fireman to do this or that and then go off and leave him to his own devices. Firemen have about the average percentage of human nature and are liable both to err and to forget. An unfortunately large percentage do not care a —— bit, and between them the chief engineer, the superintendent and the manager must devote a good deal of time to the fire room if good results are to be obtained.

The Electric Crane in the Foundry

By HARRY SAWYER

A Paper Presented at the Recent Cleveland Meeting of the American Foundrymen's Association

It is not the purpose of this paper to enter into a technical discussion of the electric crane, but such a presentation of the subject as will lead to a better understanding between makers and users cannot fail to be mutually profitable.

The use of the electric crane in the foundry doing heavy work has become so general that even a reference to the older methods, by way of comparison, seems uncalled for.

It may be interesting, as a bit of history, to note that the first three-motor electric traveling crane built in the United States, and probably in the world, was for use in a foundry. It was put in operation only a little over seventeen years ago. Although it was constructed from the wreck of an old rope-driven crane, it did good service night and day for nearly ten years. It was the invention of Alton J. Shaw, then employed by the E. P. Allis Company as a designer, and was used in the foundry of its Reliance works, at Milwaukee.

There have been some interesting phases in the development and introduction of the electric crane. The skepticism of those in need of such machines, and the opposition of those engaged in the manufacture of the earlier types, was to be expected; but it is only fair to say that the users of cranes were quicker to recognize the advantages of the new type and to adopt it than were the makers of the old.

The use of the electric motor and the sliding contacts, solved in so satisfactory a way the problem of transmitting power to a moving machine, that the traveling crane rapidly superseded the swinging crane in nearly all classes of foundry work where a crane is required. In one notable instance,—pipe foundry work—the swinging crane was retained. Whether this was due to some peculiarity of the work that made the circular pit and the circular movement essentially better than the rectangular pit and corresponding crane movements, or whether it was due to the natural persistency of established practices, seemed for a time to be an open question; but the recent equipment of several pipe foundries with traveling cranes indicates that the latter was the correct explanation.

It is no doubt true that the foundry has set the standard of excellence for electric cranes. Some shops and mills may have heavier loads to handle and require greater speed, but the crane manufacturer recognizes that the perfect control required in the foundry represents a higher state of development than mere requirements of capacity and speed. It should not be understood that good control is not required in mills and shops, particularly the latter; but as a rule the requirements of the foundry are much more exacting.

The conditions under which a foundry crane is operated are less favourable to continued good service than the conditions in a machine shop. It is more subject to overload, and the dirt and dust necessitate more careful attention; furthermore, the men directly responsible are usually less familiar with machinery, with the result that the crane too often does not have the care that it should. It is a mistake to assume that a crane which does the work of an army of labourers can safely be handled and cared for by one of that class. The importance of employing only thoroughly competent and conscientious operators, and keeping the crane in perfect repair cannot be too strongly urged. Prompt attention will reduce the total cost of repairs and the extra cost of careful and competent men will be saved many times in the more constant service and longer life of the crane.

There is at the present time something of a demand for excessively high speeds, and the motives of the manufacturers who advise against them are sometimes misunderstood. It is not that the problem presents any difficulties from the manufacturer's standpoint. He may prefer to furnish a standard article, from considerations of cost and delivery, but oftener he is considering the direct benefit to the customer and the indirect benefit to himself. The manufacturer and user may recognize the same advantages and disadvantages, but from their different standpoints they do not see them in the same proportion.

The one advantage sought in high speeds is a saving of time, but this is often overestimated. Take for example a 10-ton crane with full-load speed of 20 feet per minute. We may assume that the average load will not be more than one or two tons, that the average speed for such load will be 30 feet per minute, and that the average lift is five feet. Allowing 50 per cent. more time for acceleration from a state of rest, we find the time for an average lift to be 15 seconds.

If the speed of hoist were doubled, it would at first appear that one-half of this time, or 7½ seconds, would be saved. If twenty lifts were made per hour, the result would be a saving of only about 4 per cent. of the time. When it is remembered that many of the lifts must be very slow, regardless of what the crane is capable of doing, and that traverse movements are usually started as soon as the load is clear of surrounding objects and before the hoist movement is stopped, the actual saving is reduced to a very inconsiderable amount of time.

Where a large floor area is covered, a greater saving can be made by increasing speeds of horizontal movements, but the swaying of load which results from high speeds and sudden starting and stopping, sets a limit to the saving that can be made in this direction.

Two objections may be offered to excessively high speeds. First, the accidents that are likely to result from putting a high-speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. Second, if the crane is not usually run at full speed, there is a constant loss of power in the rheostat, and unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in foundries, and with least force to cranes in mills where much higher speeds are necessary and practical.

Next to the requirement of necessary strength in all parts for absolute safety, the most important point to be considered is perfect control of the hoisting mechanism. This depends upon three parts, namely, the motor brake, the load brake, and the controller.

The motor brake is released by the current which operates the motor, and should require only as much current as is necessary to drive the machinery without load. It should be sufficiently powerful to bring the armature to a stop promptly, but without shock, when the current is interrupted.

The load brake is a far more important part. It must allow the machinery to run freely in hoisting, but prevent the load from descending, except when the motor is run in the lowering direction. In most, if not all, forms of load brakes now in use the brake is applied by the action of the load. They may be divided into two classes: One in which the brake pressure is not reduced in lowering, but the motor acts with the load to cause the brake to slip; and the other in which torsion of the motor in the lowering direction reduces the pressure between the surfaces, allowing the brake to slip and the load to descend.

The most common of the first class is the enlarged step-bearing on a worm shaft. It can be used only in connection with worm gearing. It is a very simple and may be made a very satisfactory working brake. The most serious objection to it is this: If proportioned to give a fair margin of safety with the best conditions of lubrication, it will take considerable power to lower with moderate or poor lubrication, for the motor must overcome any excess of holding power over that necessary to sustain the load. This extra work in lowering means loss of time and power, and greater wear of parts.

Of the second class, there are two types, namely, the coil type and the disc type. Both have their advantages and disadvantages. The disc type is more substantial in construction, gives better distribution of pressure over the friction surfaces, and consequently a much lower unit pressure; and as the pressure is strictly in proportion to the load, it gives higher speeds in lowering light loads. It has this disadvantage, that it is more sensitive to irregularities in lubrication.

In the coil brake, the pressure and wear are concentrated principally at one end. While the brake is applied by the action of the load, the pressure and resistance to slipping are not strictly in proportion to the load. The torsional effort of the motor to release the brake is dependent upon the proportions of the brake parts, and not upon the load; hence the speed in lowering is approximately the same for all loads. Both types are used by reputable builders, and both may be designed to give good results.

A good controller is indispensable to a satisfactory crane. The essential parts of the controller are the resistances and the means for varying the amount of resistance in the circuit, according to the speed and power required. The most common practice is to divide the resistance into sections, connect the sections together in series and connect each section to one of a series of corresponding contacts. A brush is arranged to pass over those contacts, cutting more or less of the resistance into or out of the circuit. Various materials may be employed and details used to obtain the desired result, but certain conditions must be complied with if satisfactory results are to be secured.

The total resistance may be sufficient to allow the passage of only enough current to start the motor at a very slow speed with its smallest load. The number of sections must be sufficiently great and the resistance of these sections sufficiently small that no sudden or abrupt changes of speed will occur from the time the first contact is closed, sending the current through the resistance, to the time that all the resistance is cut out and the motor is given full current.

Durability of the controller and convenience in making repairs are important considerations. The construction should be such that neither the resistance material or the supporting insulation will be injured by the heat. Conservative rating and good ventilation are required to keep the temperature down to a safe point. Sparking and burning of contacts cannot be entirely prevented, but proper proportion of resistance to avoid great changes in voltage between consecutive steps, and a well-designed magnetic blowout will prevent serious burning. The brushes and contact pieces must be renewed occasionally, and they should be very accessible. It is important also that the resistance material should be removable without moving the controllers from their positions in the operator's cage. Economy of space, so far as it is consistent with proper sizes of parts, good ventilation, good insulation and accessibility, is of importance.

Crane motors are usually series wound. It seems almost unnecessary to say that they should be very simple and strong mechanically, that the electrical insulation should be of the best quality, and that they should be designed to stand great variations in speed and load, and sudden reversals under load without injurious effects. The highest possible efficiency at some one speed and load is not so important as a good average efficiency over a wide range. Motors of low or moderate speeds are preferable on account of the reduced gear ratio required between motor and winding drum or driving wheels.

Referring in a more general way to the design of cranes and the problems and limitations met by the designer, it is the exception rather than the rule, that he has free hands to do as he might wish. Limited space, close approach of hook to roof, sides, and ends of building; perfect accessibility of all parts; a large factor of safety; low price,—these are some of the requirements which, desirable as they may be, are not always compatible.

Manufacturers and users have underestimated the advantages to both of getting together. The manufacturer should understand fully the requirements of the user, and the user should know the full effect of the limitations he places upon the manufacturer.

The Electrification of Steam Railroads

At the recent convention of the American Railway Master Mechanics' Association, a report was read on the electrification of steam railroads. The committee was appointed to consider and present the relative advantages of the different systems of electric traction now in use as applied to interurban and suburban lines, and, as far as possible, the relative cost of electric and steam operation. The different systems of gasoline, gasoline-electric and steam motor cars were also considered.

It is perfectly apparent, says the report, that the density of traffic is the ruling factor as to whether the steam or the electric road will prove the more profitable.

It is quite well known on old-established lines what the passenger returns will be with fairly steady business conditions, provided there is no change in the train accommodations, but if there is an increase in train service it is almost sure to build up an induced traffic, the amount of which is difficult to estimate. Unless, therefore, there is a reasonable basis of expectation for such traffic, the steam railway that can fully care for its own is not in need of a new system, and the expediency is doubtful. On the contrary, there are many sections of the country, well populated and suburban district, where an increase of travel may be induced by improved facilities, the amount of which can be gauged by the density of population.

Absence of smoke and cinders, open cars in season, connections with city lines, all add to the popularity of the trolley and give a business that can be profitably carried at lower rates, which, after all, is the main inducement. It is believed, therefore, that where there is a sufficient density of traffic it will pay steam railroads to handle their local suburban and interurban travel electrically, giving frequent trains and frequent stops, equaling the convenience and accessibility of trolley lines, for which the public does not have to stop to consult time-tables, buy tickets and go to inconvenient points to get on trains. Traffic of this kind should have its separate tracks, as it would get in the way of fast through trains and itself would be impeded by slow freight trains, using the same tracks.

It would be possible to make a combination service in some territories, running slow freight through at certain hours when travel was light, or, if the character of the freight would permit, to have special separate freight units which could keep out of the way of passenger traffic. The committee believes, however, that few situations will figure out profitably with the combination service, and that if electrification is warranted for passenger traffic, a complete change will be desirable, except possibly where there is through travel involved also.

In discussing the relative advantages of systems of electric traction now in use, the report deals briefly with the direct and the alternating-current systems.

As to the relative cost of operation by electricity and by steam, very little accurate information could be obtained. The results obtained by attempting to draw comparisons from hypothetical roads would depend entirely upon the assumptions which were made. For instance, a set of conditions could be assumed which would show a much lower cost of operation by electricity than by steam; another set could be assumed which would show practically equal cost, and a third set which would show that steam operation would be the most economical. In view of the fact that the assumption would govern the results, it is believed that information of this nature would not be of value to the association and might lead to erroneous assumptions and misunderstanding.

A number of electrifications are under way at the present time, employing various systems of distribution, and a considerable amount of data will no doubt be available in the near future.

Relative subjects which would be of interest and value are the character of the shops, shop equipment and apparatus necessary for the maintenance and repair of electric equipment, also the power houses and their equipment.

It is recognized that the so-called motor car, one carrying its own motive-power plant, whether gasoline, gasoline-electric or steam, occupies a distinct field of usefulness. On many branch lines, now existing, where travel is light, and on new extensions into unsettled country where the business will not return a profit on steam train service, it would have to be run at a loss until a sufficient business was induced or built up by the travel facilities afforded. These situations are the distinct field of the motor car, which can be operated for less per car-mile than by regular steam train or electric methods until the volume of business will warrant the regular transportation methods.

The use of motor cars on the Union Pacific is for picking up passengers on branch lines. In delivering passengers at connecting points for through trains, the service of these motor cars is exceedingly lucrative. The matter of giving the branch-line patrons of any steam road increased service, with more frequent trips per diem, is very much appreciated by the local community, and their good will is beneficial.

On the hypothesis of the same density of traffic, with the same class of service as would be encountered on one of the ordinary branch lines of the territory west of the Missouri River, the cost per mile for local train service, equipment consisting of two cars and a locomotive, would be about 24 cents, including repairs, fuel, oil, labour, cleaning, etc.; this is for passenger, as well as baggage, mail and express service.

Electric service equipment, consisting of one-car and trailer, figuring that the density of traffic is sufficiently regular to warrant it 7 days a week, would cost about 18 cents a mile.

The gasoline service, mechanical drive only being considered, consisting of one car and trailer, with baggage, mail and express service, would cost 15 cents per mile. This, of course, would be independent of whether service was six days or seven days per week, the cost simply depending upon the service rendered.

Railroads, therefore, have a choice of the various systems proposed, and a study of the conditions to be met and facilities afforded, both in the way of care and maintenance, as well as the train service proposed, will give the elements by which each situation will have to be studied. The motive power departments will be called upon to participate more and more in advising as to these questions, and in order to be qualified to undertake such work it is very desirable to introduce information and discussion of these subjects.

Alternating-Current Systems of Distribution and Their Automatic Regulation

By CHARLES W. STONE, of the General Electric Company

A Paper Read at the Atlantic City Convention of the National Electric Light Association

THE subject naturally divides into two sections, the first section covering the general subject of primary and secondary distribution, and the second section covering general theory and descriptive matter in regard to the different types of automatic regulators which are now available.

In dealing with the theory of alternating-current distribution, two sides of the system have to be considered: the primary and the secondary. In order that a direct comparison may be made between the different methods of primary and secondary distribution, it seems wise to discuss them separately.

PRIMARY DISTRIBUTION

Several different systems are now in use in this country for primary

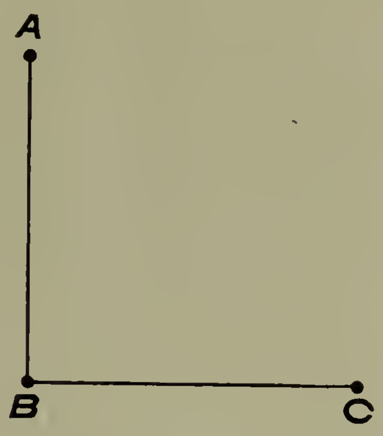


FIG. I.—TWO-PHASE, THREE-WIRE SYSTEM

distribution. The five principal ones will be taken up as follows:—

Single-phase, two-phase three-wire, two-phase four-wire, three-phase four-wire, three-phase three-wire.

SINGLE-PHASE

The first alternating current used for lighting was all single-phase, and was distributed from the main generating station by means of a number of single-phase feeders, which were run to the different sections of the town, feeding individual transformers located near each of the consumers.

This system was in many ways very simple to manage and is desirable at present if properly carried out. The principal disadvantage is that it is not well adapted for a power load, except where comparatively small motors are used. If all the generators be run in multiple, the single-phase circuits be carried to different sections of the town, and the secondary system be properly designed, individual automatic feeder regulators can be installed and very good regulation can be obtained.

There are now practically no new single-phase systems being installed,

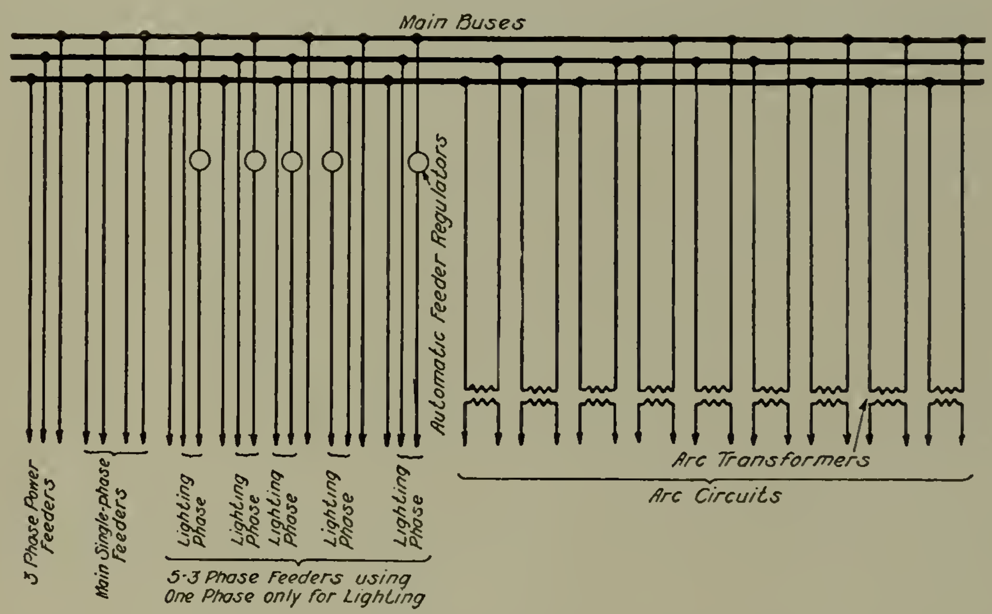


FIG. 2.—THE SYSTEM OF FEEDER CONNECTIONS USED IN SCHENECTADY, N. Y.

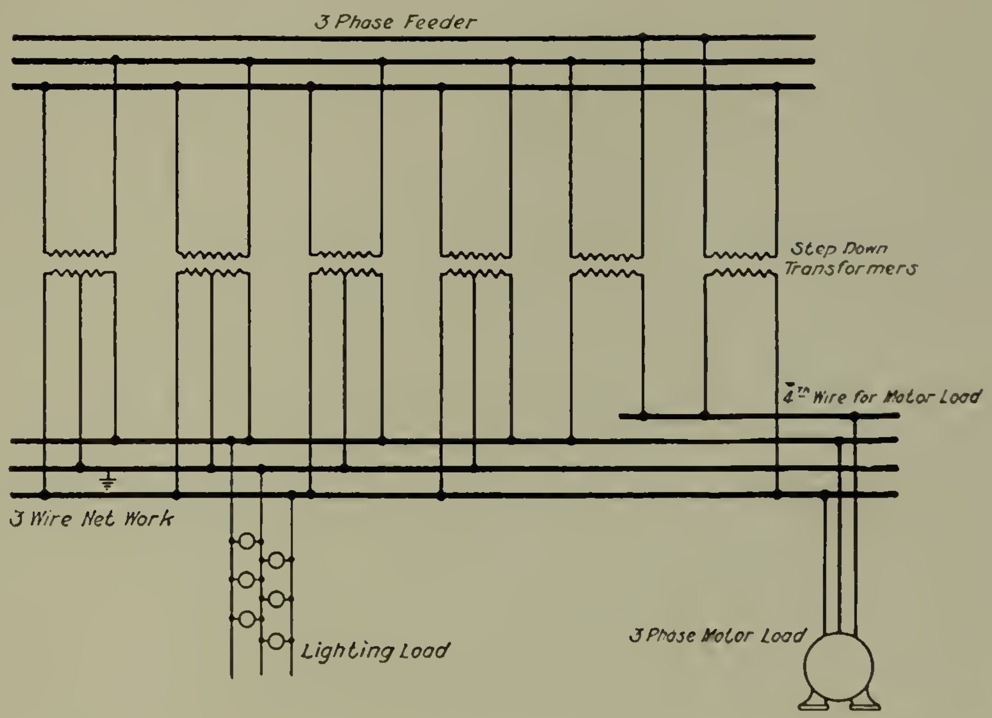


FIG. 3.—THREE-WIRE SECONDARY NETWORK, WITH FOURTH WIRE FOR POWER

and it therefore does not seem desirable to dwell on this subject at any great length.

TWO-PHASE THREE-WIRE

This system is a step in advance

over the single-phase system, in that it has the great advantage of being able to take care of a power load in addition to the lighting load.

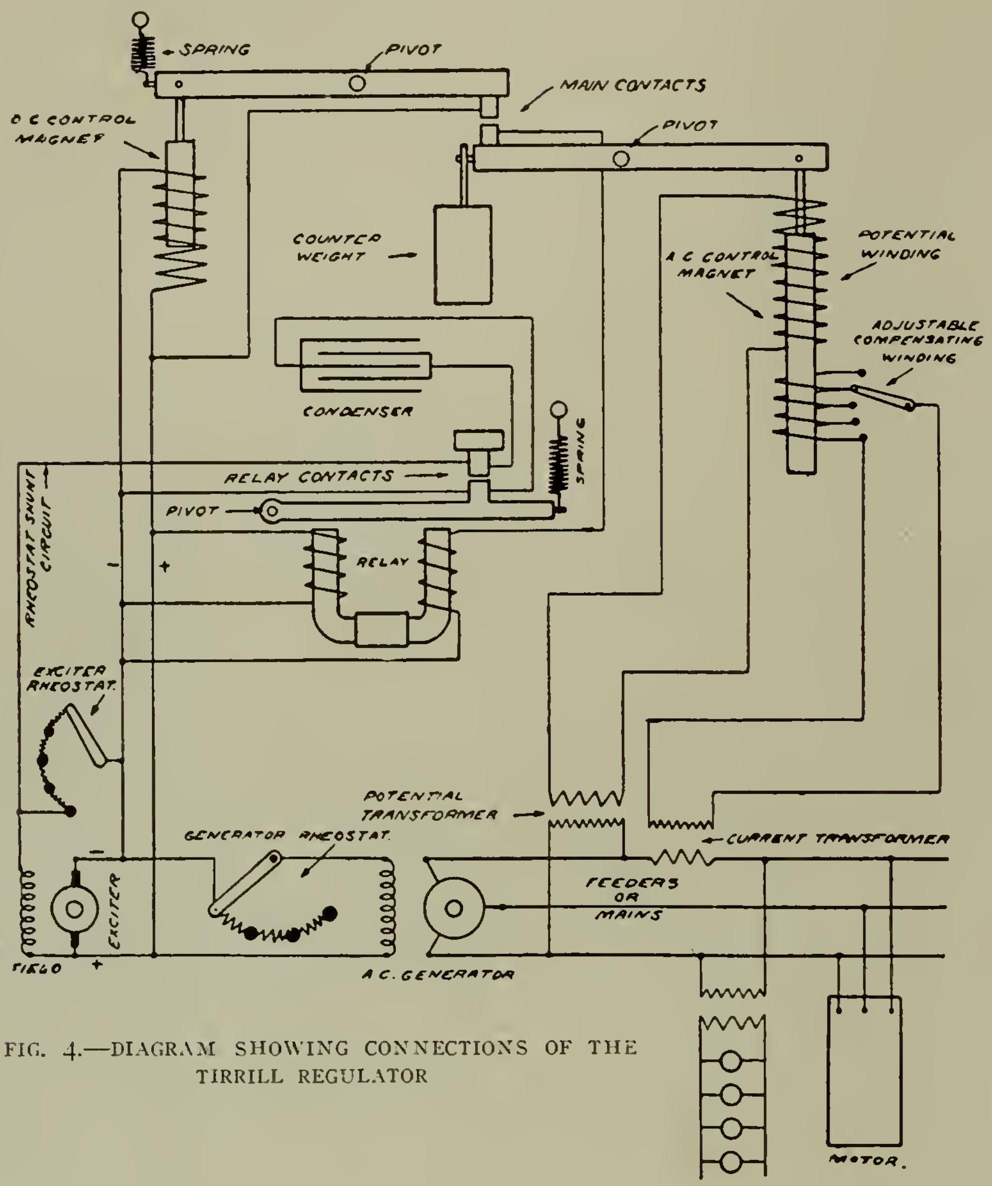


FIG. 4.—DIAGRAM SHOWING CONNECTIONS OF THE TIRRILL REGULATOR

This system is obtained by connecting together one side of each of the two phases, thus obtaining a third wire which acts as a common return for the two phases. Two-phase circuits can be run to different sections of the city; the lighting can be distributed on the two phases and power load can be fed from both phases.

The principal objection to such a system is that the load on one phase reacts under certain circumstances in such a way as to affect the other phase, thus making it very difficult to obtain good regulation. The third wire must also be made large enough to carry the resultant current of the two phases. It is therefore 40 per cent. larger than the other two wires.

One other objection might be pointed, and that is that the potential between the two outside wires is considerably higher than the potential across either of the phases. That is, the potential between wires *A* and *C* in Fig. 1 is $\sqrt{2}$ times the potential between *A* and *B*, and between *B* and *C*, which means a higher potential strain to ground. This means a higher potential with no decrease in copper.

There are very few systems of this kind now in use in this country, and in most of the places where it has been abandoned.

TWO-PHASE FOUR-WIRE

This system is very desirable in many ways for both lighting and power. It does not have the disadvantage above mentioned of the two-phase three-wire system, as each phase can be kept independent; lighting can be done single-phase, distributing the different single-phase circuits on the two phases, and carrying the power on both phases. Of course, such a system requires more copper than the three-phase, as all four wires must be carried out for any power load.

The two phases are interconnected at their middle or neutral point in some cases, thus making it possible to ground this point, and thereby reducing the potential to ground on the circuit. In other cases, both phases are kept absolutely independent.

The first arrangement seems undesirable, on account of the fact that considerable complications are caused in the switchboard and its appliances, and a ground on any of the four wires would be a short-circuit on that phase. If the neutral is not grounded and the two phases are interconnected, simultaneous grounds on any two wires would affect both phases. If the phases are kept entirely separate, a disturbance on one phase need not necessarily affect the other phase, and the switchboard and its appliances can be very much simplified. It is doubtful if this arrangement is ever as desirable as the three-phase with single-phase lighting feeders.

THREE-PHASE FOUR-WIRE

This system has many advantages, the principal one being that it is possible to obtain a higher voltage on the circuit, thus reducing the amount of copper necessary or increasing the distance to which power can be transmitted economically without having a higher potential on the line between line and ground than would exist on any other system.

This system is obtained by connecting together the three phases of the generators or transformers in Y. Thus the potential across the outside wires is $\sqrt{3}$ times the potential of each individual phase. When the system is balanced, the neutral wire carries no current and therefore is usu-

FIG. 5.—AN AUTOMATIC FEEDER REGULATOR

ally made smaller than the outside wires.

There are a number of large installations using this system of distribution, such as the Chicago Edison Company in its outlying districts, the Cincinnati Edison Company, the Toledo Traction Company, the Union Heat, Light & Power Company, of Covington, Ky., the Consumers' Light & Power Company, of Duluth, Minn., and others.

The usual practice in such a system is to run single-phase circuits from the station, distributing the different single-phase circuits between the outside wires and the neutral. If any power load can be obtained, the other two wires are installed, or if a large block of lighting or power can be obtained at some distant point, all

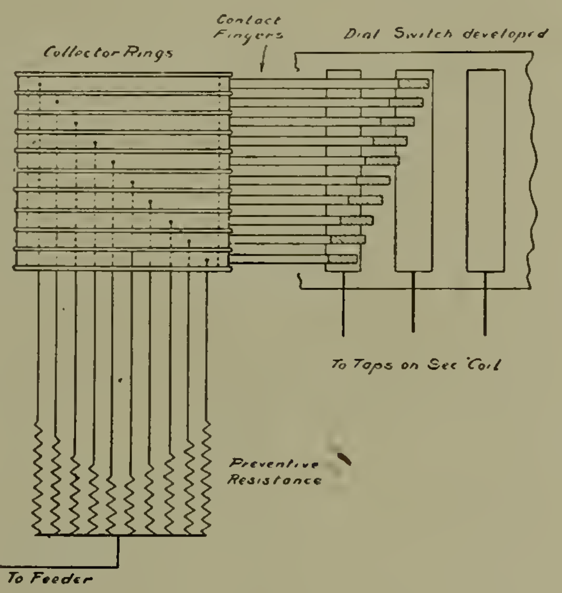


FIG. 6.—CONNECTIONS OF SWITCH AND RESISTANCE FOR AUTOMATIC FEEDER REGULATOR

four wires are installed, and the lighting can then be distributed between the outside and the neutral wires, and the power can be distributed on all the three phases in the usual manner.

Most of these systems are operated with a grounded neutral. This neutral, however, should be grounded only at the main station, as all kinds of disturbances to telephones, etc., would occur if the neutral is grounded outside the station.

The writer has recently had called to his attention a peculiar incident which has happened in Milwaukee, which has in operation a three-phase four-wire grounded neutral system, this system being grounded not only in the main station, but also at the transformers.

It was noticed that at times a considerable amount of direct current would exist in the neutral wire of the three-phase four-wire alternating system. This matter was investigated and found to be current from the railway system, that is, it was noted that every time a car started up somewhere out in the outlying districts a fluctuation in voltage was noticed on the alternating-current system, thus proving conclusively that

FIG. 7.—COVER OF THE SWITCH-TYPE REGULATOR WITH CONTROLLING MECHANISM

the neutral wire of the three-phase four-wire system was conveying back to the station part of the return current from the railway system.

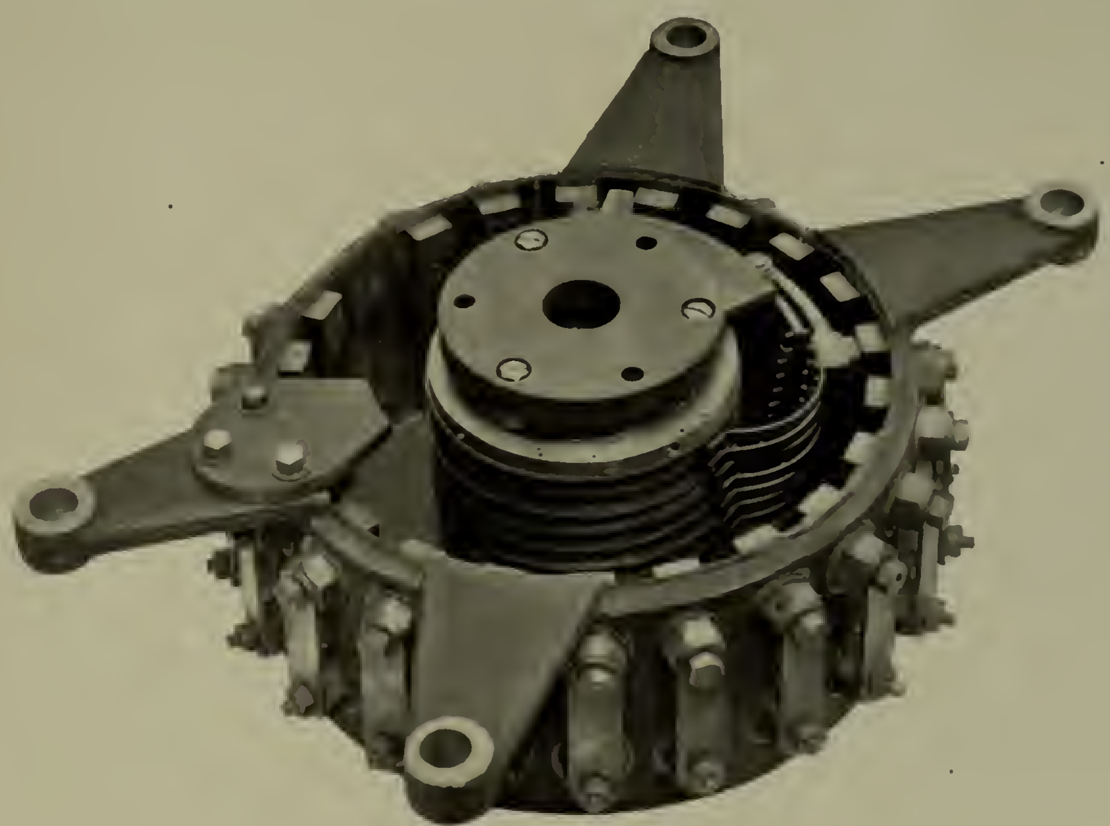


FIG. 8.—THE SWITCH OF THE AUTOMATIC FEEDER REGULATOR

THREE-PHASE THREE-WIRE

This system, if properly installed, is a very satisfactory method for lighting cities of average size. Less copper is required than in the two-phase four-wire system, and it is also superior in many ways to the two-phase three-wire alternating system.

In laying out a three-phase lighting system, the best method is to make provision so that all circuits leaving the station may be three-phase, each circuit, however, carrying all the lighting on one phase, the third wire

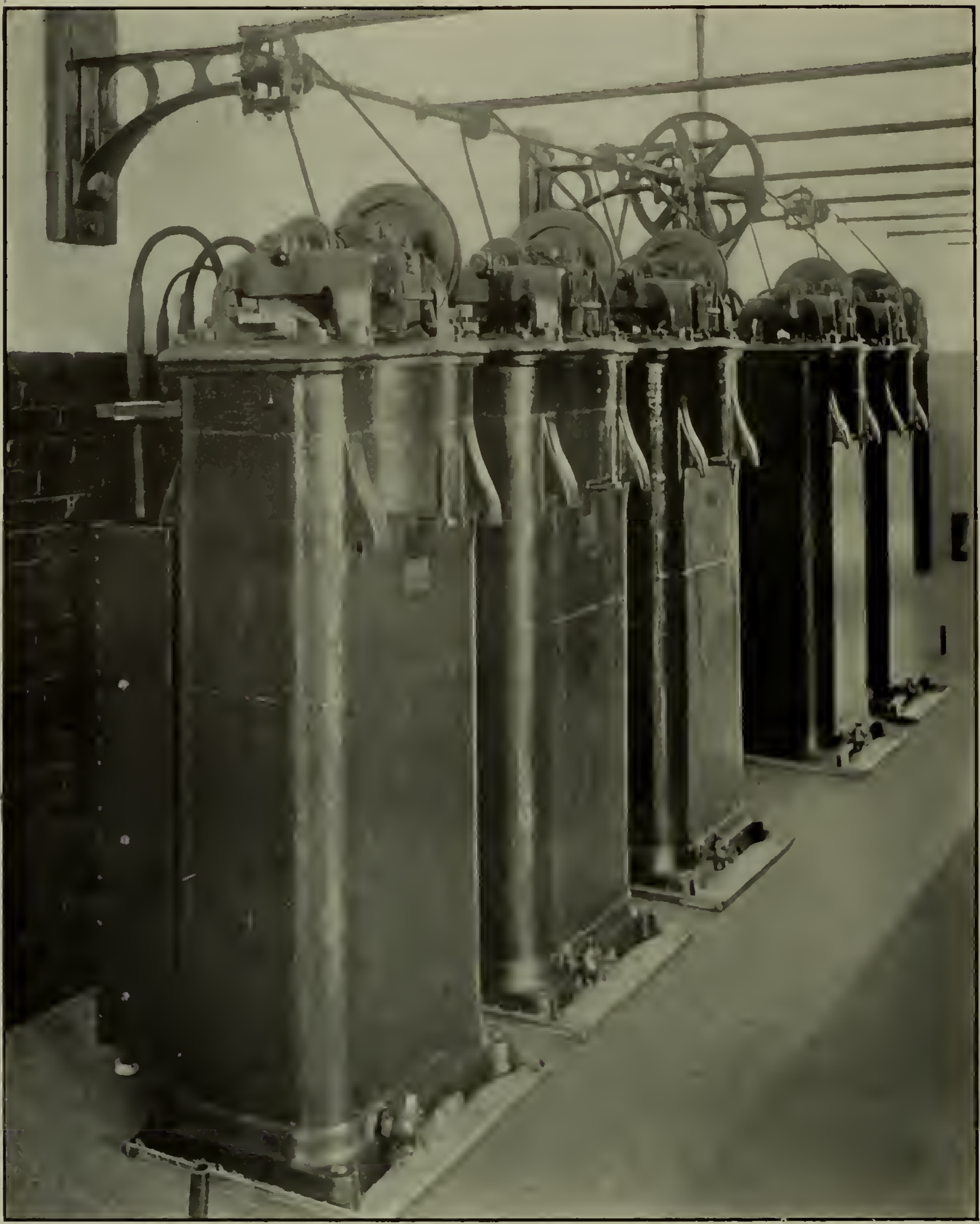


FIG. 9.—AUTOMATIC FEEDER REGULATORS IN THE DOCK STREET STATION OF THE SCHENECTADY ILLUMINATING COMPANY

being simply for any power work which can be obtained along the line of the feeder. The third wire would not necessarily have to be run at first, and would simply be installed when any power work is developed. It is possible to regulate the lighting phase of this feeder by several different methods, so that extremely good regulation can be obtained, and no attention need be paid to the other two phases.

As the power load on such a circuit increases, the tendency toward balancing the circuit is increased, the motors tending to take current from the other two phases; under certain circumstances, they would even tend to feed back current into the lighting phase. Such an arrangement causes no trouble in the motors unless the unbalancing in potential is considerable.

In order that the unbalancing of the bus-bars at the station shall be as small as possible, the lighting fed by the different circuits should be distributed on the different phases, that is, all the lighting on feeder No. 1 should be connected to phase *A*, all the lighting on feeder No. 2 should be connected to phase *B*, all the lighting on feeder No. 3 should be connected to phase *C*, and so on. If the load on the different circuits is not approximately the same, by connecting the lighting load of, say, two small feeders on to one phase and the lighting load of other individual feeders to the other phases, a good balance can be obtained.

If the street lighting is done by a constant-current transformer system of some kind, it is possible to connect this load to one, or perhaps two, of the phases, and possibly do all the lighting from the third phase, thus obtaining a balanced condition.

Each system, however, will be a separate study by itself, and if the above general rules are observed, there is no reason why the best possible regulation will not be obtained with the fewest number of devices, and with the least amount of trouble.

In order to illustrate this method of distribution a little more fully, the diagram in Fig. 2 shows the arrangement of the feeders which was adopted in Schenectady, N. Y., when the new station was built. This method of distribution was adopted after giving the matter considerable thought and study, and has proved very satisfactory in every way since its adoption. It will be seen that the main bus-bars are three-phase and that eight circuits run from the station.

The central portion of the city is fed by two single-phase feeders. These two feeders are run through the main business street of the city, one feeder on each side of the street. As most of the load on these feeders is for stores and shops of different kinds, the peaks correspond almost exactly. These two feeders are run as single-phase feeders, and the third wire has never been run, as it proved in this case to be more economical to run a separate three-phase power feeder for this section of the city. Both of these feeders are connected to the same phase of the main station bus-bars, and a Tirrill regulator is installed to regulate the potential of the bus-bars and to over-compound for the potential drop of these two feeders.

All the other feeders of the city are run as three-phase feeders, the lighting on each feeder, however, being done entirely from one phase, the third wire being run entirely for the incidental power work, such as ice-cream freezers, small power motors and similar devices. Individual regulators of the automatic type are installed in the lighting phase of each of these feeders. The arc load is fed entirely by constant-current transformers, and the different transformers are connected to all three of the phases.

By an arrangement such as outlined above, it will readily be seen that the total range of the individual feeder regulators is reduced to a minimum, that is, the total range of regulation necessary on the regulators is determined by the difference in the peaks of the load of the individual feeders and the unbalancing of the main bus-bars. In actual practice it was found that the peaks of the different feeders corresponded very closely, and by balancing the system as outlined, the unbalancing in potential of the bus-bars was very small, being seldom more than 1 per cent.

Thus the total range necessary on the regulators was very small.

SECONDARY SYSTEMS OF DISTRIBUTION

The secondary side of the system is one that requires very careful consideration and constant watchfulness, in order that proper regulation can be obtained; this is also the part of the system from which, if carefully watched and intelligently administered, the greatest sources of economy can result, both in amount of copper required and in the reducton in core losses of transformers.

The 220 to 110-volt, three-wire secondary system of distribution has proved to be the most satisfactory in almost every particular. The three-wire system is simple and is readily understood by the average operator and lineman. All three wires can be carried into all the customers' premises where the load amounts to more than six to eight lights, thus making it possible to obtain the very best balance; yet the copper required for such a system is considerably less than that required for a two-wire, low-voltage secondary system.

If the three-wire system of secondary distribution is used, the neutral or middle point of the secondary of the transformer should be grounded. This is advisable from several standpoints and it is assumed that all are familiar with the discussions that have taken place in regard to this point. The writer will, therefore, not enter any further into the discussion of its merits.

If the single-phase primary system is used, the secondary system is very simple, as a complete three-wire network can be installed, and can be fed at different points by the different feeders. If, however, either the two-phase or three-phase systems are used, it is necessary to have a number of different networks; each network being fed by the feeders connected to the different phases of the main bus-bars.

This has many advantages, and also some disadvantages. In case of trouble in any one section, if this section is fed from one phase it does not mean necessarily that any other section of the town that is fed from some other phase of the bus-bars is affected. However, on the other hand, the more complete the secondary three-wire network, the better is the regulation.

If the three-phase, three-wire system described above is used, a three-wire network can be fed for lighting from one phase of the feeder, and this network can be fed by single-phase transformers installed at, or as near as possible to, the center of the load. Other transformers can be installed connected to the other phases for obtaining a third wire for feeding the power load. If the primary of the feeder can be carried into the customer's premises, a three-phase transformer might be installed for the power load. There are, however, some cases where it would be desirable to run a fourth wire around through the section fed by the feeder connected as shown in Fig 3.

In planning any system of distribution, it is very important to make such arrangements that it is possible to eliminate the primary line losses by means of regulators. These losses being usually a large proportion of the total losses, by eliminating them it is possible to obtain exceedingly good regulation. Both the three-phase system, with the lighting carried on one phase of each feeder, and the three-phase, four-wire, with the lighting carried on the individual phases connected between the outside wires and the neutral, are particularly well adapted for the installation of automatic regulators, as direct control can be had of the lighting phase.

The secondary being in both cases a single-phase, three-wire system, the control of the lightning phase on the high-tension side of the system means the direct control of the voltage of the three-wire network. It is, therefore, not only possible to compensate for the line loss on the high-potential side of the system, but the losses on the low-potential side can also be partly eliminated.

The three-phase, four-wire and the three-phase, three-wire secondary systems have been used for secondary distribution. Both of these arrangements are very bad and are not to be recommended at all, as it is not possible to get good regulation.

AUTOMATIC REGULATORS

There are two types of regulators which should be considered under this head:—

Regulators that are arranged to work directly or indirectly to change the potential of the generators.

Regulators for operating directly on the feeders.

The most successful type of regulator now in use for regulating the potential of the generator is one that is called the Tirrill regulator. Fig. 4 shows its general working characteristics.

There are two main controlling solenoids, one energized from the alternating-current generator that is to be regulated, and one energized from the exciter circuit. Each of these solenoids contains a movable

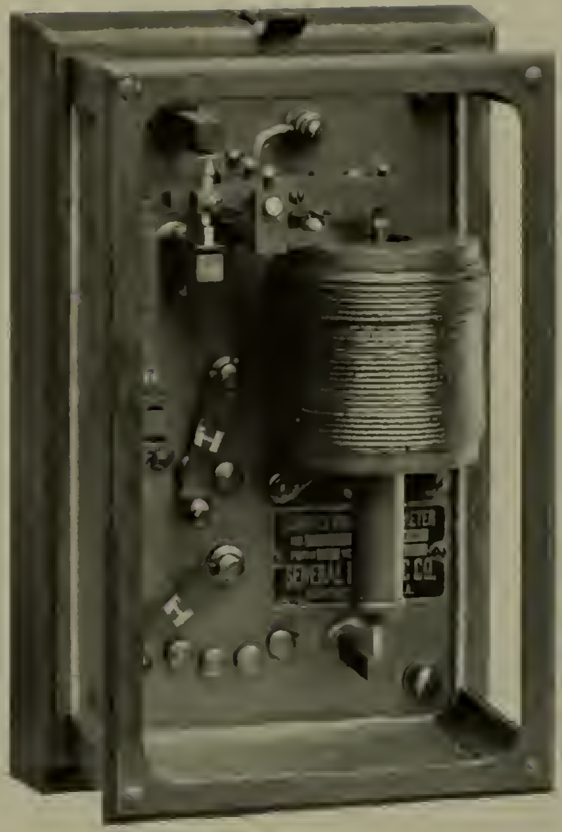


FIG. 10.—POTENTIAL RELAY, OR CONTACT-MAKING VOLTMETER

iron core which is hung on a balanced lever carrying a platinum point at its other end. When the alternating-current generator is operating with a light load, the exciter voltage is at a minimum, and the pull of the exciter solenoid is therefore much weaker than when the alternating-current generator is fully loaded, and the exciter voltage at a maximum. It will therefore be seen that the place of contact between the platinum points varies in space relatively to the load carried by the alternating-current generator, and hence it has been very aptly termed a "floating contact."

When these contact points are closed, the relay magnet is energized from the exciter circuit, and this in turn closes the main contacts that short-circuit the resistance in series

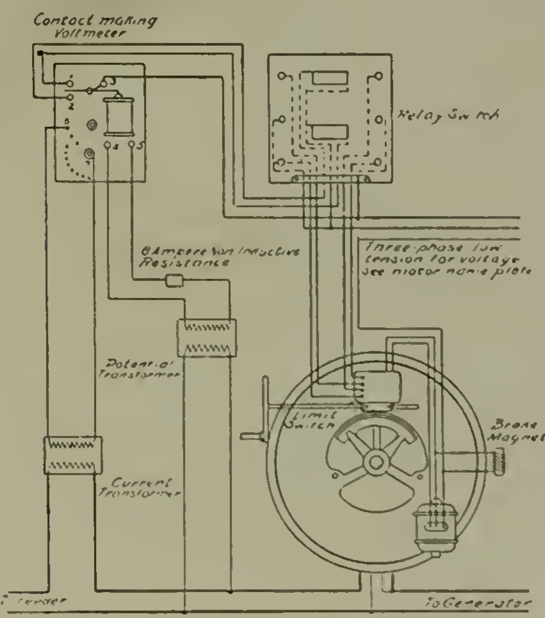


FIG. 11.—DIAGRAM OF CONNECTIONS OF POTENTIAL RELAY

with the exciter field. The main contact points may thus be made large and heavy so that they will not readily wear or burn away, and the power of the relay magnet insures a positive make-and-break action.

By the application of a simple compounding device to the alternating-current solenoid, any desired voltage can be constantly maintained at a center of distribution distant from the generating plant, under varying conditions of load, the station voltage being raised and lowered automatically in direct proportion to the current flowing.

AUTOMATIC FEEDER REGULATORS

Two types of automatic feeder regulators are now obtainable. Both of these types of regulators are transformers or compensators in principle. One of these depends on the movement of a dial switch and the other is dependent on the shifting of the magnetic flux through the two coils and cores.

Fig. 5 shows the dial-switch type of regulator. Two sets of coils are wound around a core like the core-type transformers, one of the coils being connected across the circuit, and the other coil connected in series with the circuit and provided with a number of taps which are connected to the dial switch.

A dial switch for an automatic regulator must be so designed that it will be light, and thus have little inertia, and must also be rugged in its construction in order to stand the wear and tear of constant operation. It must also be so designed that there will be no burning of the contacts.

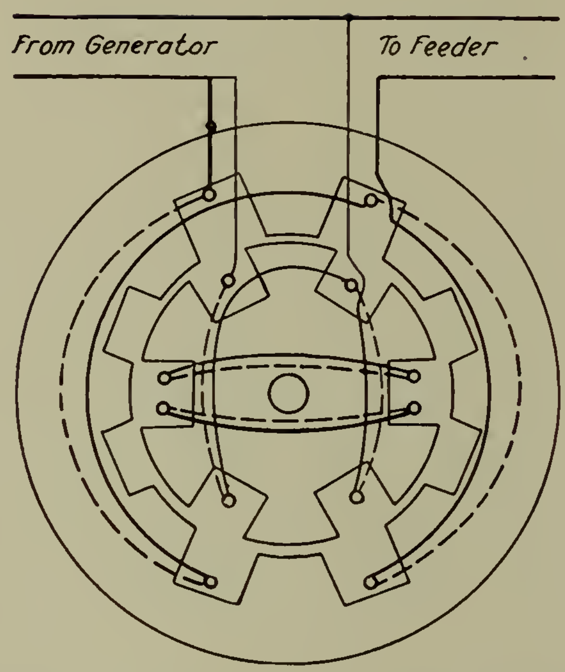


FIG. 13.—DIAGRAM SHOWING CONNECTIONS OF SINGLE-PHASE INDUCTION REGULATOR

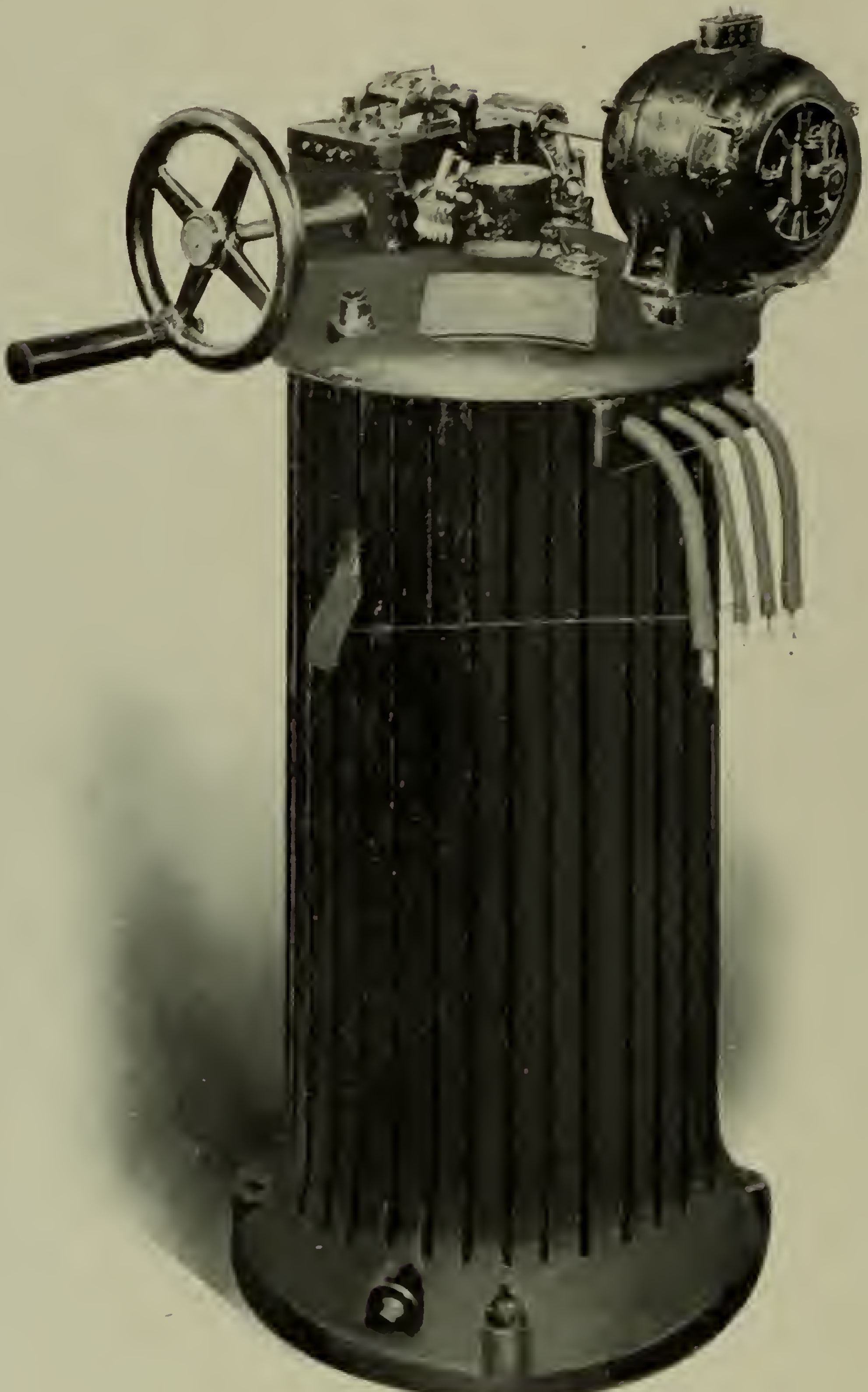


FIG. 12.—AN AUTOMATIC SINGLE-PHASE INDUCTION REGULATOR

This switch consists of three separate parts, namely, the stationary contacts placed on the inside of a cylindrical cast-iron pot, the stationary set of collector rings and the moving part which carries the contact fingers.

The moving part is shown in Fig. 8 very clearly, and consists of a metal carrier which has mounted on it ten fingers of different length, all insulated from one another. These fingers bear on the contacts of the stationary part, and are also connected to the ten collector rings on the central stationary part.

It will be seen that by thus designing the contact arms several of these fingers are in contact with the stationary contacts at the same time. If these fingers were not insulated from one another, a short-circuit would take place between the taps on the transformer. They are therefore insulated from one another and a resistance is connected between them.

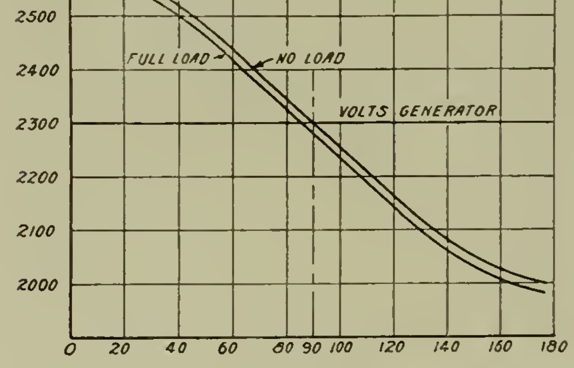


FIG. 14.—CURVES OF VARIATION IN FEEDER VOLTAGE BY ROTATING PRIMARY CORE OF INDUCTION REGULATOR 180 DEGREES

This resistance limits the flow of current between the different taps. By this means, several fingers being in contact at all times, no sparking can possibly occur. Fig. 6 shows the systems of connections of this switch.

The operation of this switch is very simple, as may be seen from Fig. 7. To the top of the switch arm is attached a beveled gear, and on opposite sides of this gear are two magnetic clutches. A shaft is run through these clutches and on the end is mounted a fly-wheel, which is belted to a motor, or, in case there are a number of regulators, it is belted to a line shaft. This shaft is kept in continual operation; thus if one or the other of the magnetic clutches are energized, the pinion attached to it is rotated, and it in turn rotates the switch arm. A limit switch is provided, so that if the switch completes its motion in one direction or the other, the operating circuit of the clutch is opened, stopping the movement of the switch.

The entire moving part of this type of regulator is so small and light that it can respond very quickly, and thus it is impossible to make it hunt. Fig. 5 is a view of the regulator complete, and Fig. 9 shows a typical installation of a number of these devices.

POTENTIAL RELAY

It is necessary to use a potential relay, which energizes one or the other of the two magnetic clutches. This relay is shown in Fig. 10. It consists of one simple solenoid, in which is placed a movable core. This core is attached to one end of a lever, on the other end of which are two platinum contacts. Additional contacts are so placed above and below this lever that any movement of the plunger in the solenoid will close one or the other of these sets of contacts. With the switch type of regulator the closing of one or the other sets of contacts will energize one of the magnetic clutches. With the induction type of regulator, instead of operating directly on the motor circuit, the circuit of either one or the other of the solenoids of the reversing switch is closed.

Fig. 11 gives a good idea of the system of connections. A very simple method of compounding is provided, which is exactly the same as that used on the potential coil of the Tirrill regulator already described.

AUTOMATIC SINGLE-PHASE INDUCTION REGULATORS

This type of regulator is built on an entirely different principle from that described above. It is in principle a variable ratio transformer, or rather compensator. The regulator is made with a primary or shunt winding, which is connected across the line. It also has a secondary or series winding, which is connected in series with the line. The primary or shunt winding is placed on a movable core, and the secondary or series winding is placed on the stationary core, as is shown graphically in Fig. 13 on the opposite page.

The shunt winding produces a magnetizing flux that has a constant value, the direction of which is constant in the movable core. But the direction is variable with respect to the secondary core, and consequently with respect to the series or stationary winding. The passing of this flux through the secondary coils in one direction induces a potential in these coils which is added directly to the line potential, or subtracted when the direction of the flux is reversed by rotating the primary core through an angle of 180 degrees.

FIG. 15.—PARTS OF AN INDUCTION REGULATOR

FIG. 16.—REVERSING SWITCH TO REVERSE THE DIRECTION OF THE MOTOR USED ON THE INDUCTION REGULATOR

As the core is rotated gradually, the direction of the flux, and consequently the amount forced through the secondary coils, is similarly varied, and produces gradually a varying potential in the secondary from the maximum positive through zero to the maximum negative value.

The effect of rotating the core through its entire range is shown graphically in Fig. 14, which shows the variation in the feeder voltage with no load and full-load current flowing. The slight difference in these curves is due to the loss of the

FIG. 17.—A THREE-PHASE REGULATOR

regulator itself, and represents the entire loss of the device.

The rotating core is provided with two windings: the active or shunt winding connected across the lines, and a second winding which is short-circuited on itself and arranged at right angles to the former. The object of this short-circuited winding is to decrease the reactance of the regulator. If the movable core were not provided with a short-circuited winding, and it were rotated from one position to the other, a gradually increased potential would be required to force this current through the series winding, thus causing poor power factor on the feeder.

By adding this winding, however, the reactance of the regulator is cut down to the minimum, and thus has very little effect on the power factor of the line. In this respect it is vastly superior to any of the other resistance and reactance types of regulators heretofore built.

The amount of reactive effect on the feeder is directly proportional to the range of regulation of the regulator, that is, as the range in the regulator increases, the effect on the power factor of the circuit is increased; thus with a 20 per cent. range on the regulator, the power factor of the feeder would be lowered only a trifle over 1 per cent., and with a total range of 10 per cent. it will be lowered about one-half of 1 per cent. The efficiency is extremely high, on account of the fact that the regulators are built on a very small diameter of punching, and are all built with two poles.

The moving mechanism consists of a segment of gun-metal which is keyed to the shaft. This segment engages with a worm gear, which is mounted on the extension of the motor shaft. The motor can be either direct or alternating current, and is designed to have a very high starting torque in order that the regulator can be started quickly. A simple magnetic brake is used to bring the regulator to rest quickly.

By referring to the Figs. 12 and 15, a good idea of the appearance of the complete regulator and its essential parts can be had.

A reversing switch or relay is used to reserve the direction of the motor. This switch is shown clearly in Fig. 16 and needs no further comment. Mechanically, they are very substantial. The coils are all form-wound and are fitted into the slots in the punchings; they are therefore not subject to any mechanical injury. A potential relay is used to operate the reversing relay, and is exactly the same as that described above for use with the switch type of regulator.

AUTOMATIC THREE-PHASE REGULATORS

At present there is only one type of automatic three-phase regulator available. This regulator is of the induction type, and is built on exactly the same principle as the single-phase induction regulator described above. The windings are all three-phase instead if single-phase, and are distributed in the slots on the cores of the stationary and rotating part, in exactly the same manner as on the single-phase.

Regulators of this type are particularly useful when used on transmission circuits to sub-stations. They can be installed either in the main station or in the sub-station. If such regulators are used on the main three-phase feeders feeding sub-stations, from which are distributed single-phase lighting feeders, it is possible to install automatic single-phase feeder regulators on the different lighting circuits, and thus the very best possible regulation would be obtained. Fig. 17 gives a good idea of the general outside appearance of regulators of this type.

Distributing Telephone Directories in New York

ON June 25 the employees of the New York Telephone Company began the work of delivering the new summer telephone directories and collecting the old ones. About 200 men are employed for this task, which takes about four weeks to complete, and means the handling of about 800 tons of paper, since the old books are taken away when the new ones are left. This is done for the protection and convenience of the subscriber, and to prevent the use of the old directories, which would result in the giving of many wrong numbers, and would be, in consequence, a drag on telephone service.

The new directory contains the names of over a quarter of a million of New York's most progressive business houses and individuals. Books to the number of 365,000 will be distributed. Originally the telephone book was used only for the purpose of looking up telephone numbers, but at the present time the list of telephone subscribers in New York is so complete that the telephone directory has become one of the best general directories of New York and vicinity, and is almost absolutely accurate, since it is revised and a new issue distributed every four months.

An advertisement recently issued by the New York Telephone Company illustrates graphically the extent to which this feature has grown. It is in the form of a picture showing side by side Mount Everest, the highest mountain in the world, and a tower of 365,000 telephone books, one on top of another, which makes a column 6¾ miles high, towering over a mile above the top of the mountain. The present edition filled twenty-five freight cars and weighed four hundred tons.

An electric baggage truck is being experimented with by the Pennsylvania Railroad at Altoona, Pa. It is about the size of an ordinary baggage truck, but is much heavier, owing to the electric apparatus required. It is operated by the handle, and has a speed of about three miles per hour. Safety appliances have been provided whereby, if, while the truck is in motion, the handle suddenly drops to the ground, the truck will stop. By turning a rod to the right or left, the truck can be moved forward or backward. When the power is off it cannot be moved, the rear wheels being automatically locked by machinery.

The Present Status of the Electrolysis Situation

By PROF. F. C. CALDWELL, of Ohio State University

THE disintegrating effect of electric currents on underground pipes and cable sheaths, as a factor in the operation of electric railways, was first brought to the attention of the electrical public in 1893, and there began a period of agitation and investigation which seems to have reached a maximum about 1901. Since that time, although the matter has been continually before the operators of electric railways and of water and gas distributing plants, much less has been heard of it; this is probably partly due to the much improved condition of railway return systems through the country, and partly to the general conclusion that the danger has been considerably exaggerated. As, however, the effect of the current must in many instances be a slow one, it is well, from time to time, to look over the field and note the progress of events.

There are certain well-established facts concerning this so-called electrolysis, some of which may be stated as follows:—

Whenever a lead-covered cable or an ordinary pipe line lies parallel to an electric railway track, or lies in such a position as to form a connection between the tracks and the power house, there will always be found in it more or less current, which, however, may be made very small by taking proper precautions.

When this current leaves the cable or pipe and passes into the soil, electrolysis is liable to result, in a degree depending upon the current density, the character and dampness of the soil, and the metal of the pipe. The presence of salts in the soil facilitates the action, so that the same condition as to amount of current flowing will produce very different damage in different cities. Furthermore, the effect on lead is much greater than on iron, and greater on steel or wrought iron than on cast iron, so that lead service pipes and lead-covered cables are especially liable to trouble. The greater thickness of cast-iron pipe is also in its favour, as compared with the other materials mentioned.

As a consequence of these facts, we find the generally accepted policy that the drop in the track return must be kept as low as practicable by the use of first-class rail bonding and by the application of return feeders where they are needed. It is also generally acceded that it is particularly important to prevent the passage of any considerable quantity of current from the pipes through the ground to the rails, and the use of bonding conductors from the pipe or cable to the rails or to the negative pole of the generator is quite commonly recommended.

The wisdom of this policy is unquestionable in the case of cable sheaths, and probably also in the case of steel pipes with screwed or riveted joints, because in these cases a proper application and maintenance of such bonding wires should stop all passage of current into the soil, and thus entirely do away with the electrolytic trouble.

As a result of this policy, the telephone companies usually accommodate the railways with a large capacity of lead return feeders free of cost, but are glad enough to do it in order to save themselves from injury. It is reported that at one place in Brooklyn from 200 to 300 amperes are taken care of in this way.

This practice is also not uncommonly followed in the case of cast-iron pipes, and is justified by many engineers. It is, however, a well-known fact that the resistance of the leaded joints in such pipes is often quite high, and if the joints are located in moist conducting earth it seems inevitable that there would be some flow of current through the soil around the joints; also if the current flows in appreciable amounts electrolysis is sure to follow. This point has been insisted upon by many who have made a study of this subject, and cases of pitting supposed to be due to such joint electrolysis have been reported.

On the other hand, there are many who claim that this action is inappreciable, and that no consideration need be given to it. This, of course, has a very pronounced bearing on the question of whether such pipes should be bonded to the rail so as to materially decrease the resistance of the path through the pipes and thereby attract an increased proportion of the return current. That such bonding does produce this effect, at least in some cases, is indicated by the data of a German system where the removal of the bonding wire reduced the current flowing through the pipes from 30 amperes to less than 1-10 of an ampere.

On the other hand, it is reported that the bonding of the gas pipes to the rails in Brooklyn about six years ago marked the beginning of a period of freedom from electrolytic troubles which succeeded one of serious damage from this cause. It would appear that this question cannot be regarded as settled, but that there is not conclusive evidence that electrolysis at the joints is to be anticipated.

The possibilities of a system of overhead return feeders properly located and effectively connected to the rails seem not to have been generally appreciated as a means of keeping the current out of the pipes. The cross-section of iron conductor which the rails of a heavy double track, or even single track, offer to the return current, is such that the drop through the rail when the joints are properly welded and bonded becomes very small, except when the traffic is very heavy. Take, for example, the case of two tracks of 90-pound rails well bonded. We have the resistance per thousand feet equal approximately to $\frac{0.3}{W}$ ohm per track, where W is the weight per yard. This would give approximately 1-600 of an ohm per thousand feet of track. With an averge of two heavy cars running over such tracks, the average current might be as much as 200 amperes, which would give a drop of ⅔ of a volt per thousand feet. Taking as a rough approximation the resistance of 6-inch cast-iron pipe as about 0.8 ohm per thousand feet, as found by Blake, we shall have the current that will result from this, even if the track is bonded directly to one thousand feet of main, to be less than one ampere; and with the usual insulation intervening between track and pipes, this insignificant current would be still smaller. This shows that in most systems the return feeders would not need to run far from the centre of the system.

In large systems, it is often advisable to adopt a regular feeder and main system, similar to the Edison system of distribution of light and power, the tracks constituting the mains, and the feeders so placed and so designed that the whole track system may be maintained at about the same voltage, with the current flowing from both directions through the track toward each feeder junction. While this system would not make the most economical use of the rail return, from the point of view of railway operation, and would necessitate a larger expenditure for overhead return feeders than economy of operation would indicate, the results which can be obtained by it would seem to be a most conclusive answer to the statement that a double trolley is the only means by which appreciable electrolysis can be prevented.

In connection with this, it is interesting to note that while several suits to compel railroads to adopt double trolleys have been introduced, no double trolleys are yet in use as a result of such suits. In Peoria, Ill., the Lower Court granted an injunction, "subject to reasonable conditions." In Dayton, Ohio, the Court of Common Pleas declined to compel the railways to put in the double trolley, and this decision has been virtually upheld by the Circuit Court.

The insulating effect of concrete, used in the roadbed, has an important bearing on the subject, as has also the waterproof qualities of good modern pavements, which by keeping the soil between the rails and the pipes dry, both increases the resistance and decreases the electrolytic effect.

It has often been assumed that the presence of pitting in pipes is conclusive evidence of electrolysis. This conclusion, however, is entirely unwarranted, as exactly similar results are produced by certain chemicals in the soil. The destructive character of soil where ashes have been used as filling is well known.

Turning next to the question of co-operation on the part of the owners of underground metallic structures for the prevention of electrolysis, we find, as noted above, that the telephone interests have, in general, accepted the situation and taken effective steps to end the difficulty. In the case of the gas and water systems, however, the question of joint electrolysis has stood as a barrier in the way of effective co-operation along the same lines as those adopted by the telephone companies.

Ever since the early days of electrolytic troubles the question of so constructing cast-iron pipe lines as to increase the resistance to the flow of return current has been a mooted one. Various expedients have been suggested, such as the insertion of occasional lengths of insulating tube; the use of pine as packing for the joints in place of lead, as has been done in St. Johns, N. B.; and the use of cementing materials other than lead, such as sulphur and iron filings or Portland cement. In connection with the latter material, recent reports from California indicate that very satisfactory results in its use have been obtained in Los Angeles, and that it has been adopted as a standard method of construction for water supply systems.

It is also stated that, apart from the question of electrolysis, the use of cement joints in gas pipes has been increasing in favour, and that now even 30-inch pipes are so installed. In one case in Los Angeles a comparison of two similar water pipes, one cemented and the other leaded, with a rather high voltage applied, gave in the leaded pipe one hundred and twenty amperes, but with the cemented joints less than three amperes. These figures would seem to justify a thorough consideration of this method of avoiding the difficulty; though, of course, were the bonding of the rails particularly bad the trouble might only be accentuated by such a course.

Such reasonable precautions as the locating of new pipe lines in alleys, or at least as far from the tracks as possible, the surrounding of the service pipes with vitrified tile where they cross under rails, turning the bells of the pipe toward the power house, and similar precautions, would seem hardly to require argument.

A recent extensive investigation of this subject is embodied in a paper read before the International Congress at St. Louis by Prof. G. F. Sever. This contained a large amount of data given by various railways and municipalities with regard to the conditions existing in their respective cases. The following summaries are of interest:—Out of one hundred and two railways reporting, thirty stated that electrolysis had occurred in connection with their systems, and in twenty-two cases claims had been made against the companies; forty-one, including nearly all the larger plants and many smaller ones, use return feeders. It should be borne in mind that the thirty cases where electrolysis is reported to have occurred cannot be regarded as including all instances where the damage is going on, for with others the trouble may be in progress, but may not yet have developed far enough to attract attention.

Of twenty-nine reports made to various municipalities twenty-two indicate the presence of electrolysis. Of course, such reports often follow the first detection of this sort of trouble, and the large percentage of electrolysis cases is, therefore, natural. A summary of the various city ordinances gives the following drops as permitted in the tracks of different cities:—

Chicago—½ volt per 300 feet or 8.8 volts per mile.
Battle Creek—⅛ volt per 200 feet or 3.3 volts per mile.
Atlantic City—¼ volt per 200 feet or 6.6 volts per mile.
Philadelphia—⅛ volt per 200 feet or 3.3 volts per mile.
New York—25 volts maximum difference on the whole system.
Berlin, Germany—2 volts maximum difference on the whole system.

Of the twenty-five published expert opinions, four state that the trouble from electrolysis cannot be eliminated so long as the single trolley is used; ten state that it can, and eleven avoid the question.

One question which has been discussed since the earliest days of electrolytic troubles, and which has just come to be of much practical importance, is that with regard to the electrolytic effects of alternating currents. Many opinions upon this subject have been expressed, both pro and con, and some results of laboratory tests have been published, the conclusions of which have not been very concordant. The first case, however, where actual conditions of operation have been closely approximated seems to have been in an investigation recently published by S. M. Kintner. In these tests several iron and lead pipes were buried, and subjected to a 25-cycle current of from three and one-half to seven amperes under about 25 volts pressure. This current was maintained for a period of one year, at the end of which time there was no evidence of electrolytic action. Two weeks of direct current at 20 volts on a similar piece of pipe resulted in pitting 1-16 inch deep. Interesting though these results are, their importance would be much greater if there were more prospect of the alternating-current motors being employed for city railway work.

To sum up the situation, we find that while there will always be need of vigilance, both for the railway man and the pipe owner, there is no good reason to suppose that practical immunity from electrolysis may not be had without giving up the present standard methods of distribution.

The Organization and Conduct of a New Business Department

For Central Stations in Cities of 50,000 Population and Under

By M. S. SEELMAN, JR., of the Edison Electric Illuminating Co., of Brooklyn

Some time ago, it will be remembered, the Co-operative Electrical Development Association offered three prizes, $500, $300, and $200, for papers on the subject treated here. The competition was open to central station managers and their employees in the commercial department. The first prize was awarded to Mr. Seelman, whose paper is given here.—The Editor.

THE writer was recently in a number of cities, not alone of 50,000 and under, but of 100,000 and over, where the central station had not only no organization for securing new and retaining old business, but no sense or appreciation of the lack of it. These companies do no advertising, make no attempt to educate their public to a knowledge of the superior advantages of an electric service, have no special propositions, employ no canvassers.

Some of them do not even follow up the permits for new buildings. They give no suggestion to the customer as to the most economical and effective methods of lighting his home or store or factory; that is left to the wiring contractor, who in all likelihood has an exceedingly primitive and limited idea of illuminative engineering. The attitude of such a central station may be thus expressed:—"Here we are. If you really want to buy current from us and are careful in arranging necessary preliminaries and formalities, we will agree to supply it to you."

In one city of about 50,000 inhabitants, not one hundred miles from New York, the customer, before being permitted to do business with the central station, must come to the company's office and sign his, or her, name in a big book kept for that purpose.

The business that comes to these central stations drifts in. If the station makes money it is rather in spite of itself than because of itself, and, under the circumstances, sooner or later the municipal ownership propaganda is certain to take strong hold. There is need of stirring up and enlightenment. These stations must "awake, gird up their loins and go forth to do battle" for business.

If asked what the company, awaking from its lethargy and desirous of securing the possible business within its sphere of operation, should first do toward establishing an effective commercial organization, the writer would say:—

Hire a good man, if possible one familiar with the kind of work he will be called upon to do; a man under forty, if possible; better still, under thirty-five. If one can be secured with a combination of technical and commercial knowledge, not necessarily an engineer, but a man who has been trained around a central station, who knows something about generating and distributing methods, and has tackled lighting and power problems before, so much the better. He will have the less to learn.

But, above all, he must have "ginger," he must be a hustler with red blood in his veins, and in his heart the zest for labour and the pride and loyalty of the service. If the time comes when expert or technical knowledge which he lacks is needed, that can be bought for him; but we cannot buy the energy, the dash, and the vim if it is not there.

There are many such men to be had. Sometimes we find the very man in charge of some smaller central station. A good place to look for him also is among the employees of the larger companies, where the live young man is likely to have had a more comprehensive experience than would have been possible in a smaller station, and still, because of peculiar conditions, to be working for a wage which would make an offer well within your limit personally flattering and financially attractive.

This man should have charge of the organizing and conducting of our new department. Let us consider him as having been installed and call him the general agent.

The first step the general agent should take is to establish a first-class and highly attractive office and show-room. This should be located on the main street or principal square of the town. If the company's offices are already so located, he can alter and utilize them, or a portion of them, for the purpose. But if, as is too often the case, the offices are on some side street at a distance from the business centre, or even, as frequently happens, in the generating station itself, somewhere on the outskirts of the city, then the general agent must get the company to either move its entire offices, bag and baggage, to a main location, or else hire for his department alone a suitable store.

The former course is recommended, so that every time a customer comes in to pay his bill, or anybody enters the office for any purpose, he must necessarily see the exhibit of electrical appliances and utensils. Thus the law of suggestion comes into play, and the visitor becomes more or less interested in those things to which we desire to attract his attention.

This new office and show-room must be made bright and attractive. The colour scheme should be a creamy white that will reflect the light to the best advantage. The electrical exhibits should be as varied and complete as possible. A great many exhibits can be secured at little cost from manufacturers, who will be glad to co-operate with the central station for the advantageous display of their wares.

The windows of this office must be utilized to illustrate different methods of show-window lighting. Arranged on separate switches can be shown exhibits of trough incandescent lighting (as by Frinck reflectors), incandescents in combination with cone or Holophane reflectors and Nernst lamps with the special Nernst reflectors.

The common method of window lighting by means of projecting incandescents running around the sides of the windows, or by chandeliers, may also be shown, but in this case care must be taken to explain to customers that wherever the object of the lighting is to display the goods, then one of the three first-mentioned systems of reflected light from hidden sources is the more desirable, while the visible lamps,—projecting or in chandeliers,—may be used to advantage only when the object is not so much to draw attention to the goods as to attract the eye to the window itself, as with a saloon.

In the show-window itself should be placed an exhibit of electric fans and heating appliances, such as irons, water and food heaters, coffee percolators, chafing dishes, stoves, toasters and grids, heating pads, curling irons, and the like. Adjacent to each appliance place a neatly painted or printed card naming the article and a definite price for its use, thus:—

THIS ELECTRIC IRON
CAN BE USED
ONE HOUR
FOR
SIX CENTS

If there is room in the window, a sewing machine operated by a motor should be prominently featured and kept running, as a moving object attracts more attention than a still-life exhibit. If preferred, a buzz-saw or a coffee mill might be thus utilized instead of the sewing machine. Two or three handsome reading lamps will add a touch of art and colour to the window.

An exhibit of various types of lamps should be installed in the office. These should include arc lamps (one showing the concentric diffuser), one, two, and three-glower Nernst lamps (there is a simple, but highly artistic five single-glower Nernst lamp fixture which could well be made a part of this exhibit), meridian and high-efficiency lamps, Cooper-Hewitt tubes, turn-down lamps,—such as the Hylo,—and attractive and efficient clusters, such as the arc burst and the pagoda reflecting arc. Holophane glassware could be shown as an annex to this exhibit.

Two or three types of panel signs, individual letter signs and transparencies should also be installed in this show-room, if there is space for them; novelties in signs and transparencies should be added from time to time.

The balance of the exhibit should be made as complete and interesting as is possible within a reasonable expense limit. There must be a motor exhibit, of course, and, among other appliances that could be given a place in the show-room might be mentioned these:—

Electric pump, organ blower, forge, drills and lathes, coffee mill, combination electric meat chopper and coffee mill, dough mixer, ice-cream freezer, vibrators, dental machinery, prepayment meters, theatre dimmers, electric vacuum carpet cleaner, a motor operating a refrigerating machine, a motor operating adding machine, the Gray telautograph.

In a prominent place over the desk which his canvassers are to occupy the general agent should have a sign hung, reading:—

DON'T TALK VOLTS AND AMPERES;

TALK DOLLARS AND CENTS.

This brings us to the subject of canvassers. The general agent will, of course, take steps at once toward securing the aides required in his campaign for new business, the principal questions that arise being how many does he need, in what manner shall he secure them, and how much ought he to pay them.

The solution of the first question must be governed, to a considerable extent, by local conditions,—the industrial, commercial, and residential nature and status of the town. Roughly speaking, it might be said, that other things being equal, a city with 50,000 population or less, which is alive and fairly prosperous, would require one canvasser to about every 12,500 population.

This is an elastic rule, however, and must be freely interpreted. For instance, the writer has in mind a factory town in New England with a population of 100,000, of which 35,000 are mill hands, comparatively few of which would be "prospectives." In deciding upon the number of canvassers needed there, that 35,000 would receive but scant consideration. Take it, then, that we start with one canvasser for every 12,500 population, and these we can lop off or add to as future conditions and contingencies may show to be necessary.

To secure the men we want, we must either again draught from the larger companies or advertise in technical publications. Very likely our general agent knows one or two men of the type he wants who are working for other companies, and whose services he can secure. It may be possible to take an employee from some other department of the business and put him to canvassing, but the writer's experience has been that such men are rarely effective and usually unsatisfactory. As a rule, if necessary, the writer would rather take salesmen from some other line of business and educate them.

As to remuneration, whether straight salary or salary and commission is the best method of paying, is a debatable question. The writer is a firm believer in the latter method as the one most effective for securing new business. Especially is this true in residence districts, where the householder must frequently be interviewed at night, the only time he is to be found at home. The canvasser on straight salary naturally hesitates to give up many of his evenings to this work, but if each call may mean a dollar or two to him it becomes a different proposition.

An equitable arrangement for the payment of canvassers would be about $12 per week salary and a commission of two cents per 16-candle-power lamp equivalent for all over 250 equivalents a month the canvasser turns in. In addition, the company should pay his car fares and incidentals.

Now, then, let us suppose we have gathered our selling force together and have equipped our show-room. We are still not quite ready for business.

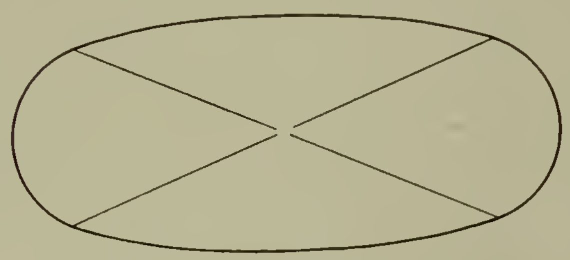


DIAGRAM SHOWING METHOD OF LAYING OUT DISTRICTS FOR CANVASSERS. THE CENTER IS THE BUSINESS SECTION, AND THE CITY IS DIVIDED ALONG LINES RADIATING FROM THE CENTER

It is advantageous to give the new men the run of the office for a day or two, so that they may become acquainted with the company's physical layout and its installation, metering and service methods. During this time the general agent can have divided the city into districts, one for each of his canvassers.

A word about this work of districting. There are many cities where the business district is largely concentrated in the centre of the town. In places of this kind it is an excellent plan,—at least to start with,—to district along lines starting at a common centre in the business section and radiating outward, as shown in the diagram herewith. In this way each man is given a portion of business section, of residence locality, and probably of power territory. Later on it may be found that one of the men is especially effective in residence work, another for business or for power propositions, and it is then easy to redistrict in accordance with the special qualifications of the men. Or again, to vary the system later on, occasionally one man may be given one line of business,—the printers or butchers or bakers, or whatever line may be selected,—to canvass right straight through, giving a report upon each one interviewed.

We are now nearly ready to canvass. The general agent gives his men a selling talk, not only to inspire them with enthusiasm, but to give them the last word of information as to how to approach and handle various light and power propositions as they may present themselves, so that the men may be competent to advise prospective customers as to matters involved in their installation, such as wiring, selection of lamps and glassware, location of switches and outlets, painting and decoration of houses and stores to produce the best and most economical lighting effects, types of motors in general most suited for special classes of power work, ideas and methods of apportioning the units in a power installation, and the like.

It is well if these instructions, together with the special propositions offered by the company, be gotten up compactly in small book or pamphlet-form and handed to each canvasser. Of course, the canvasser must be told to refer at once all propositions that he finds himself unable to adequately or competently handle to the general agent. If he starts such business he is entitled to his commission on it, even if the deal has to be consummated by the general agent or some expert or specialist.

In connection with this talk of the general agent to his men, it may be said, in passing, that it is excellent business to secure, from time to time and as frequently as possible, experts in various lines,—illuminative engineers, power men, Nernst, meridian, and high-efficiency representatives, heating appliance manufacturers, and the like,—to address the members of the business department. This helps a great deal.

Some might advise a preliminary canvass to secure names and addresses of prospectives, but the writer believes in digging right in from the start, reaching out after business from the first day. The district agent begins work about 9 A. M., and is instructed to report back at 4.30 or 5 P. M. If this is not practicable on account of distance, then reports can be limited to the morning session, the district agent arriving at the office at 8 instead of 9. Where practicable, it is better to have the agent return late in the afternoon, so that he may report on his day's business then, giving time for the general agent to go over the reports and prepare his instructions to his men for issue in the morning.

There are a number of systems of keeping track and record of canvassers' work. The card system is probably the best for a city of 50,000 or less. The district agent's daily report of his work is made out in the form of a card for everyone visited. On the card is inscribed name, address, nature of business, date visited, attitude of the person called on, prospects of doing business with him, when to call again, and the like. This is not a particularly arduous job for the canvasser, and he is not likely to call upon more than from twelve to twenty people a day.

The general agent must look these daily card reports over carefully before they are alphabetically filed away. He must especially note any difficulties or obstacles encountered by his men, and he himself must bend his best sales efforts on these specially difficult propositions. If the canvasser reports a man as positively out of the prospective class, before the general agent accepts this classification he should either send someone else to see the recalcitrant or go himself. In this way the impossibles can be eliminated and the card catalogue list becomes a list of prospectives.

This list of prospectives soon assumes proportions and furnishes the very best possible list for the effective distribution of printed matter.

This brings us to the important subject of advertising. The writer is inclined to believe that newspaper advertising is likely to be more advantageous and profitable in a small city than it is in a big one. There should be more or less of it done in every city, not only because it promotes a desirable feeling of goodwill between the newspapers and the corporation, but because it certainly has a very real educative value. In the average big city, however, the character of the population is such that out of a circulation of, say 100,000 that some newspapers have, only one or two thousand may be possible customers. In advertising, the company must pay to reach the 98,000 unprofitable ones along with the 2000 prospectives, and it is, as a general proposition, uneconomical to pay for all this surplus publicity.

In the average small city conditions are different. Circulations are not so large nor mediums so numerous, advertising charges are not so heavy, and a larger proportion of readers are likely to be prospectives, so that, for advertising in the city of 50,000 or less, the newspaper should be utilized to a considerable extent. Take a whole page or a half page once in a while on some special occasion, such, for instance, as a reduction in rate or the inauguration of some new policy or special proposition, or a marked addition to station capacity.

At other times use an advertisement each week in weekly papers and about three times a week in dailies, not all the year round, but for certain months in the year, pausing now and again to take breath and gather renewed energy for a new campaign. The size of these advertisements should not be fixed hard and fast, but should vary up from a minimum of 5 inches, single column, or 4 inches, double, according to the particular message it is desired to convey.

It is doubtful if a central station in a city of 50,000 or less would support a first-class advertising man, and the other kind is of little use,—liable to cost a good deal more than his salary. If the general agent can write a good advertisement,—and a good one does not need to be "smart" at all, it is merely the embodiment of a common-sense argument or a special proposition in an attractive form,—so much the better. He can do that part of the work to advantage, especially if it is some special proposition or announcement of local interest and value that is being made.

For general advertising of educative effect some of the advertising agencies that have made a specialty of electrical work,—notably the Curtis Advertising Company, of Detroit, and the C. W. Lee Company, of Newark,—get up clever and attractive newspaper advertisements, both text and illustration, and supply them at a price that any central station can afford. Or the general agent can secure samples of the advertisements of the larger companies by writing for them, and many of these can be readily adapted for local use.

The same rule or methods may be followed in securing advertising matter for the other and, in the writer's judgment, more valuable system of advertising by letters, circulars, booklets, and the like, distributed through the mail. The advertising agencies get up some very excellent and relatively inexpensive general educative matter which is printed with your name, and, as far as anyone who receives it knows, emanates originally from the company. In this category is the "Residence Number" of the "Electrical Bulletin," recently issued by the Curtis Company.

Letters, circulars, and the like, that refer to purely local offers, conditions and announcements must, of course, be gotten up in the home office by the general agent or an assistant, and here, again, samples of the big companies' advertisements will be of aid, if not to pattern after, at least to suggest ideas and methods of treatment. Another big help is to get a good printer, even if he costs you more. Don't have a poor printer if you can avoid it at any price. The good one is often able to aid you with ideas, suggestions, and plans for the effective construction of advertising matter.

A point that should be borne in mind is never to send out a piece of advertising matter without enclosing a return post card. A fundamental law of political economy is that man is a lazy animal. Each different branch of the business should have its distinctive return post card, so if a lighting circular is sent out, a lighting post card is enclosed; if a sign circular is sent out, a sign post card is enclosed, and the same with power, fans, heating, and refrigeration, if the company goes that far. A postal card should not be used; that is expensive; but an attractively printed post card, with the address and place for a one-cent stamp on the one side and on the other a printed form referring to the matter in hand and space for name and address of the sender.

The writer has experimented as to the relative advertising value of the penny United States postal card and the plain post card for this return work, and finds that while the cost is as six to one, the latter is nearly as effective as the former. This return post-card method gives you a fair chance to estimate the interest your advertising is arousing, and leads, if the advertising is right, other things being equal, to a continuous and often surprisingly large amount of new business.

The system of doing the bulk of advertising by mail, distribution of circulars, booklets, and the like, rather than through the newspapers, is the best because the people reached, —if the campaign is rightly conducted,—are just those desired to be reached, and with the least waste of expensive publicity. The list of prospectives is a good list to work on, and that can be supplemented by special lists for special purposes, as, for instance, a sign list composed of present store customers and stores not yet using the service, but whom it is hoped some day to secure. The sign proposition may be the entering wedge.

This brings us to another very important feature of, and factor in, a new business campaign, and that is the special propositions.

If a big share of new business is wanted, one has to be liberal, one must go half way to meet the customer, and must be willing to spend a dollar to make two.

A good many companies are ready to make extensions, even in cases where it takes quite some time to get back the original investment, not to mention a profit; yet they turn away from the proposition to supply a customer with some equipment which in a far shorter period pays for itself and gives a handsome return on the money invested.

There is a free sign proposition, for instance; it has proved "good business" everywhere that it has been tried, so far as the writer knows. A panel sign costs, complete, about $45. With overhead construction, customary in a city of 50,000 or less, to hang and connect the sign ought not to cost more than $25. Here is an investment of $70. Take 200 per cent. of the investment,—$140,—divide it into 24 parts, and offer customers free signs on a two year's guarantee of $6 a month.

The cost of the sign and installation will surely be returned well within the two years, even if the customers' current bills do not run above the guarantee (which is unlikely). As a matter of fact, the actual cost, including the proportion of operating expenses, will be returned within the first year, and all the rest above percentage of operating cost is "velvet," especially as in fully 95 per cent. of cases the customer keeps on using the sign far beyond the two years of this contract. Not only this, but each sign thus erected is a good advertisement and helps bring another, besides being, as already said, in many cases an opening wedge for other business with the customer; and title is retained to the sign, so that in case of the worst the loss must be small, as the sign, with slight changes, can usually be utilized for some other customer.

With individual letter signs, the return of the investment with profit is even more rapid than with the panel sign, because they use more current in proportion to their cost. When giving an expensive sign, however, care must be exercised as to the financial responsibility of the recipient.

Still another advantage of the electric sign proposition is that it leads the merchant to realize the advertising value of electric light, so that he burns not only his sign at night, but is also likely to get in the habit of keeping his windows illuminated some hours after closing, and this, again, leads others to do the same. Such night lighting has a far-reaching effect in creating new business for the entire town, increasing the activity and energy of its life, and materially assisting in its development.

The sign is a good advertisement to the customer, too, and economical as well. Suppose it costs him $10 a month for lighting it. How much newspaper advertising could he buy for that amount? How many circulars can he print and distribute? It would cost him that much to buy a thousand postal cards without the charge for printing and addressing them, while his sign for $10 is brightly visible for three or four hours every night to everyone who passes his store, giving it a distinctive character and "burning his name into the public mind."

The town in which this free sign proposition will not take, if it is properly advertised and pushed by the new business organization, must be dead indeed.

Then there are the special lamp propositions. There are doubtless many stores in the city, in which we are hustling for new business, that are illuminated by gas arcs or Welsbachs, which we find it impossible to touch with the ordinary standard incandescent lamp proposition. Here is where the Nernst lamp comes in, and also the high-efficiency and meridian lamps. Each has its place.

The Nernst is an attractive proposition to a customer, especially a lamp about three-glower size. It is highly attractive, even decorative, in appearance, gives a beautiful pearly-white light, and is in every way far superior to any gas lamp, being at the same time so efficient in wattage as to permit of free competition with gas. From the station's standpoint also, it is not nearly so expensive of maintenance as from some reports we might be led to believe.

If our friends who are out after new business will supply these lamps free, with free glower renewals, even with free wiring and installation for outside lamps, they will find this proposition a potent factor in securing new and profitable customers, and the stores where the lamps are placed outside will most likely soon install them inside at their own expense. The meridian and high-efficiency lamps can also be worked in the same way, either in direct-current districts or on overhead circuits, where the customer, having his choice, may select one of these types as most suitable for his purpose.

The new decorative and highly-efficient "arc" clusters that have recently been placed upon the market may be utilized to advntage where the customer is disposed to complain of the arc lamps, at arc-lamp cost of operation. They give adequate illumination of fine quality at a very low cost. With these, as with signs and other lamps, one should not be afraid to go half way to meet the customer.

A method of getting one class of new business which has worked well in at least one large city, but which might or might not be applicable to the city of 50,000 or less, can be utilized with the drug stores.

Here hours of burning are long, and the average drug store may not be able to afford the average rate for the average installation. Still one cannot cut rates for him and be consistent. An attractive advertising bulletin stand of wood and iron should be made, costing about $15, with a frame in the top portion for a placard, and beneath this pockets for bulletins and other advertising matter. Then an arrangement should be made with the druggist, now using gas, that in consideration of his permitting you to keep your advertising stand in a prominent place in his store, you will pay him a sum which, subtracted from the bills at regular rates for lighting his store by electricity, will make such illumination economical for him. The placards, bulletins, circulars, and the like, are changed once a month. It is good advertising for the central station, too, because, as a rule, the right kind of people deal in drug stores, and while awaiting the compounding of prescriptions have time to read your advertising, which is placed where they cannot help but see it.

One way to get at a gas illuminated store is to offer to draw, gratis, plans for the electric illumination of the store which will provide a lighting far superior to gas, adding materially to the attractiveness of the establishment, at a price little, if any, heavier than the storekeeper has been paying for an inferior illuminant. This can be done by selecting the right kind of lamps and glassware and arranging them to advantage. One of the canvassers could easily be educated to do this class of work. Once the plans are drawn, the storekeeper is very apt to become sufficiently interested to wire up and sign a contract.

Now as to residences and new buildings. In the average town of 50,000 there will be found about six architects, and in the town of 25,000 about three. One of the first acts the new general agent must do is to get acquainted with these architects, not alone in a business way, but also socially, if possible, so that a feeling of friendliness may spring up between them. Let him join their clubs, take them out to dinner, and the like. After this "entente cordiale" has been established, the general agent is in a position to know from the start what is taking place in the line of erecting new structures, and he is less likely to be called upon to continually fight the installation of isolated plants. Get the architects on your side.

Then, of course, the building permits must be closely followed up. Let no guilty man escape. Every new building must be wired, and the way to do this is to see the builder the day his permit is issued (before, if possible), and to follow him right up until the business is done. The same should be done with permits for alterations. When the owner is about to make alterations in his home or store, that is the psychological moment to approach him about using electric illumination on the premises. These are new business pointers that cannot be neglected.

A far stiffer proposition than the new residence is the unwired old one, and yet there are doubtless hundreds of these, even in a city of 50,000, which, if wired, would yield a fair and certain revenue. How to get them wired is the problem. The advertising helps by bringing the householder to a realization of the many advantages and conveniences of an electric service. Then it is a good plan for the canvasser to call in the daytime, get the "lady of the house" on his side, and then make an appointment for evening after supper, when the householder is likely to be in the right frame of mind, and the canvasser can meet wife,—already predisposed in his favour,—and husband together. May and June are specially good months to canvass residences in, because families who are out of town in July and August can arrange to have the wiring done in their absence, saving them some inconvenience.

But there are householders who would like to have electric illumination who do not feel that they can afford to pay out the cost of wiring in a lump sum. If these be reputable citizens, let the company help them out by financing the deal, the money to be repaid within a year, in monthly installments. If this wiring would cost $200 to $250, and that is more than the householder wants to spend, suggest to him that he wire his living rooms, — dining-room, kitchen, cellar, back parlour, parlour, and lower halls,—which can be done for $100, including fixtures.

The foregoing refers to cases where the tenant is also the owner. Where he is not the owner, the difficulties multiply. Here is a plan or scheme that might prove efficacious under the latter circumstances, and is worth while trying where neither landlord nor tenant is willing to pay the complete cost of wiring. Approach the tenant and tell him that you can appreciate the fact that he is unwilling to spend from $100 to $250 in improving somebody else's property, but that it certainly is worth something to him and his family to enjoy the comforts, conveniences and elegances of electric service. Then this proposition should be made him:— If he will see his landlord and get the landlord to pay one-third the cost of wiring, and he (the tenant) will pay another third, the company will pay the remaining third of the bill. This ought to be an attractive and paying proposition for landlord, tenant, and company.

Residence lighting can be secured also by planning on paper an appropirate illumination for some particular home and interesting the resident in these plans. It is a case of being alive and hustling.

In pushing electric heating and cooking devices some companies have acted in co-operation with the department stores. From personal experience, the writer would say that it is better for the company to act alone and let the department store do the same. Standpoints and purposes are widely different. The store sells the appliances for the profit in the sale, and the profit must be a large one, for sales are necessarily limited in number. The central station's object is not to make a profit on the sale, but to get the appliance on the system where it will use current. For a G. E. six-pound iron, for instance, the store charges $4; the iron costs the central station about $2.85, and the latter is glad to sell it for $3, if an arrangement with the store does not tie its hands. Four irons can be sold at $3 to one iron at $4.

The method which has been most successful in placing irons is to send them out on trial, putting one in every house equipped for an electric service. In the city of 50,000 or less, either one of the canvassers should be used for this purpose throughout the city, or else each canvasser should take care of his own district in this respect. Load the irons in an auto, and when leaving each iron for a trial of from thirty days to three months, have the canvasser give a little selling talk and leave a neat circular, calling attention to its many advantages. Also let him leave a postal card addressed to the company, explaining that it is possible, though not probable, in first using the iron that some trifling trouble may be experienced, in which case tell the customer not to condemn the iron, but to send the postal card, when the company's representative will call and straighten out the kinks. The iron is all right, and if followed up in this way is bound to prove a boon to the housewife and a source of revenue to the company.

As a matter of fact, these irons could be given away with profit by the central stations. They cost, say $3, and bring in a revenue of about $1 a month, which begins the minute they are placed on the system. In three months the first outlay is returned; in six months the iron is completely paid for out of the profits and becomes from that time a constant agent of profitable income. It is a day load, too. In those cities where the company my fail in securing the $3 for the irons, they should be given away.

Other heating and cooking devices are not so valuable to the central station as the iron, but they all have their place in popularizing current. The company has them displayed in the show-room. A "demonstration" should be made, an attractive young lady being hired to do the cooking, and invitations being sent out to the customers. They should be given something dainty to eat and a small souvenir of the occasion. Have your advertising and your men follow this up, and a sufficient number of appliances will be sold to make it pay.

The use of electric fans can be increased by judicious advertising and canvassing, and if the company is not afraid of complications with contractors and supply dealers, by selling them at a low figure,—at approximately cost. If there is a considerable surplus supply, they should be rented for the summer months.

The increase of business from the city itself for lighting of streets and public buildings will not be considered here. This matter is usually taken care of by some official of the company, and does not, customarily, come within the province of the new business department.

The writer has purposely kept the subject of increasing the power business to the last, because it is at once, being primarily day load, of the utmost importance to the central station, and at the same time is ordinarily the most difficult to secure.

While it is possible to secure lighting business at a higher price than is paid for other illuminants, because of superiority, and also because average installations are of such size that isolated generating plants are impracticable, to get any large slice of new power business the price must be right. Even though it be demonstrated that by cutting out friction load the energy required to turn the wheels can be reduced, if the rate for current is too high there is nothing to prevent the mill owner from taking advantage of the tip, eliminating much belting and shafts, installing motors and putting in his own dynamo. Power business is such good business that special effort to get it is well worth while. If within the limits of possibility, make the rate right to begin with.

It is more difficult to secure a good power canvasser than the other kind. If the general agent is enough of a technician and sufficiently familiar with power problems to handle this end of the business, that is a tremendous help. If not, and there is much power business in the town, then, in addition to other canvassers, a power expert must be employed.

To get power business, there must be energy, enterprise, and indomitable tenacity on the part of the power man, backed up on the part of the company by a readiness to help and a willingness to be liberal. The writer knows a general agent, who is also a power man, in a manufacturing city of 25,000 inhabitants, and he has obtained a large load of new power business for his company by the use of the qualities mentioned. He goes into a factory, indicates,—at the company's expense,—the engines in use, figures out the energy saving that can be effected by the use of motors installed to the best advantage, and finds out the cost of coal and water to the factory. He has been enabled more than once to go in and win on a guarantee not to exceed for expense of operation these coal and water charges, getting eventually from four to six cents for the current.

If the factory owners balk at the expense of motors, he offers to buy them and receive payment in installments. If installation is going to interfere with the needed operation of machinery, he agrees to install the motors at night, on Sundays and holidays. That man has "ginger," and does the business. He is now running not so very far from that ideal condition where peak is nearly uniform for at least twelve hours per day. This man's example is a good one to follow.

There is one matter that the general agent and canvassers must not lose sight of,—in the natural desire for new business, old business must not be overlooked or neglected.

As soon as a canvasser has signed a customer, the tendency is to quit him and pass by on the other side of the street. This must be avoided. The customer ought to be frequently visited by the man who took his contract, cementing an acquaintance, ascertaining and attending to his wants, and, what is of the utmost importance in more ways than one, retaining his good-will. If the customer have a complaint, it is better to relieve him of it than to let it rankle in his breast, and the complaint may be of something readily remedied. Besides, the customer may desire to add to his installation. Actually, the old customers ought to constitute one of the most fruitful fields of new business. Do not neglect them.

In line with this care of old customers, one idea which can be followed to advantge is that the bills each month should be compared, either in the metering or building department, with the bills of the previous month. Wherever any marked drop is noticed, the case should be called to the attention of the general agent. In nine such cases out of ten something is wrong, which, taken at once, may be remedied with little loss to the company. If, on the other hand, the matter escapes notice, the customer also may escape, and, at any rate, the revenue from him for many months is likely to be greatly reduced or lost altogether.

The writer has abstained in this paper from going into details as to systems of making out orders and maintaining records, of handling the business on paper after it has been brought into the office by the canvasser. The main point is to get the business. The connect orders, which are passed on to the credit man, or turned over to the meter and installation departments, are simple matters of detail that can be readily worked out as part of an easy system of making and preserving orders and records.

The organization for getting new business outlined in the foregoing has the advantage of being elastic. If fewer canvassers are required than at first figured upon, it is easy enough to lop them off; if more are needed, it is easy to get them. The writer believes that if the ideas and plans of action suggested or described in this paper are followed with a reasonable degree of faithfulness and a proper adaptation to the peculiarities and exigencies of the particular central station making the trial, the result will be such a large volume of new business that, besides more canvassers, within a year three additional members of the commercial staff will be required, as follows:—

A man to take hold of contracts as soon as they are signed and follow them up until connection is accomplished.

A secretary or assistant to the general agent, who shall attend to the mass of correspondence and fulfill the office function of the general agent while he is engaged on the outside on new business propositions.

A record and filing clerk to handle the reports of canvassers, make out orders, and assume systematic charge of the papers and records of the department.

Book News

The Morton Memorial Volume of the Stevens Institute of Technology

Published by the Alumni Association of the Institute. Size 8 x 12 inches. 641 pages. Price, $10.

A noteworthy addition to the literature of engineering education has been made by the recent publication of an elaborately gotten-up volume giving "A History of the Stevens Institute of Technology," and dedicated to the memory of Dr. Henry Morton, the first president of that institution, which ranks among the best of its kind in the world. For over thirty years Stevens Institute has turned out into engineering life a yearly growing number of young men, equipped, no doubt, as well as any institution of learning can equip a man for professional work, and today Stevens men are found allied with engineering enterprise in many different parts of the world.

A record of their achievements is virtually a record of the achievements of the school itself, and such a record is supplied by the volume in question. It makes interesting reading, tracing the development of each of the nearly 1200 graduates from early school-days to the present time,—an almost unbroken story of success.

The inception of the volume came with the exercises of the twenty-fifth anniversary of the Institute, held in February, 1897, when Dr. Morton planned a souvenir book, to include a complete account of those exercises, a history of the school, biographies of the trustees and faculty, and whatever else had a bearing upon it. Dr. Morton, unfortunately, did not live to see the completion of the work, but its programme was well carried out, and the volume, as it is, is splendidly representative of the fruits of labour intelligently directed towards the foundation work of engineering science and industry. The Stevens family,—a family of engineers,—of whom Edwin Augustus Stevens was the founder of the Institute, forms one of the several interesting chapters of the volume, concerning itself mainly with the work of Colonel John Stevens, grandson of the founder of the family in America, and of his sons, Robert Livingston and Edwin Augustus, in the early part of the last century. The development of the steamboat and the early days of the steam locomotive and steam railway, the invention of the T-rail and spike, of the elongated shell for cannon, and the building of the Stevens battery, the first iron-clad vessel to be actually placed under construction, are thus successively presented, together with an account of miscellaneous inventions by members of the Stevens family, the whole forming a story of continued interest.

Indeed, even this part alone would make the volume a most valuable one for reference use; coupled, as it is, with the succeeding chapters, records of the lives of members of the faculty in the earlier days of the Institute, all men of distinction in the applied sciences and arts, and the records of the younger men who followed them, the reader has before him a volume of fascinating interest. As may have been gathered from this brief notice, the book, published by the Alumni Association of Stevens Institute, at Hoboken, N. J., was intended mainly for circulation among its members, but a limited number of copies are still available for others interested in the progress of engineering education. To these the volume will prove a desirable library acquisition well worth the price.

Continuous-Current Armatures

By C. Kinzbrunner. Published by the D. Van Nostrand Company, New York. Size 5½ x 8½ inches. 80 pages. 79 illustrations. Price, $1.50.

This book, although originally intended as a translation of Professor Arnold's treatise on the same subject, follows that work only with regard to the commonly employed drum windings for standard machines of medium size. This was done because the author intended the present volume for students and workmen, and considered that a discussion on any but the common forms of windings would take the reader's attention from the parts absolutely necessary for him to know.

The explanations and diagrams are presented so that anyone possessing an elementary knowledge of the principles of direct-current machines should be able to understand them.

The subject is treated in three chapters. Chapter I is devoted to the theory of windings, the principle of induction being thoroughly illustrated and described, and also the action of the commutator, after which the theory of drum windings of the parallel, series, and series-parallel types is taken up. Chapter II deals with the construction of drum windings, and describes hand windings, and bar windings of the evolute, barrel, and former types. Chapter III illustrates and describes the mechanical construction of armatures.

By means of the rules given in the book, the reader can, if necessary, design other windings than those mentioned. The volume should, therefore, be found useful by designers, as well as by students and workmen.

The Practical Telephone Handbook

By Joseph Poole. Published by the Macmillan Company, New York. Size 5 x 7½ inches. 533 pages. 473 illustrations. Price, $2.

This, the third edition of the Practical Telephone Handbook, contains nearly twice the amount of text matter, about 200 more illustrations, and larger pages than the previous editions.

The author has chiefly confined himself to British practice, and mainly to that of the National Telephone Company, which, he says, is, in most particulars, the same as American practice. However this may be, it is a well-known fact that the service in Great Britain is far below that in this country.

In general, the instruments and other apparatus described are in practical use, although exceptions have been made where some special principle is illustrated in the apparatus delt with.

An idea of the scope of the book may be formed from the following headings under which the subject is treated:—Introduction; Batteries; History; Receivers in General Use; Transmitters in Practical Use; Sub-Station Apparatus; Sub-Station Instrument Connections; Intermediate Switches and Extension Instruments; Intercommunication Telephones; Switchboard Apparatus; Relay and Lamp Signalling; Small Switchboards; Larger Sub-Exchange and Private Branch Exchange Switchboards; Magneto Series - Multiple

Switchboards; Magneto Branching-Multiple Switchboards; Principles of Common Battery or Central Energy Working; Common Battery Multiple Switchboards; Junction-Line Working; Trunk Line Exchanges; Party-Line Working; Apparatus Room; The Power Plant; Traffic Statistics; Aerial Line Construction; Underground Work; Long-Distance Lines,—Pupin System; Faults and Their Localization; Electrical Measurements; Special Exchange Systems; Automatic Exchanges; Miscellaneous Applications; Appendix.

The Appendix contains that portion of the agreement recently entered into between the Post Office and the National Telephone Company, relating to transmission tests; telephone statistics of countries and cities of the world; the British standard wire gauge; notes on traffic; useful numbers; and the index.

Alternating-Current Windings

By C. Kinzbrunner. Published by the D. Van Nostrand Company, New York. Size 5⅛ x 8½ inches. 80 pages. 89 illustrations. Price, $1.50.

Similar in general appearance and tone to the author's book on "Continuous-Current Armatures," this volume may be considered as a counterpart of it. The author has here endeavoured to interest the student, the workman, and the designer with the theory and construction of alternating-current windings.

This subject is treated first with regard to the production of alternating currents. The different forms of alternating-current windings and continuous-current windings are then illustrated and described, followed by examples of dissolved continuous-current windings and multiphase windings.

Separate chapters are devoted to the construction of, and the insulation of, alternating-current windings. At the end of the book is given a list of symbols used in the text. The well-chosen illustrations and the concise, but clearly-worded, descriptions, make the book of interest and value.

Electric block signals are to be installed by the Union Pacific and Southern Pacific from Omaha to San Francisco, a distance of 1800 miles, and from San Francisco to Colton, through Los Angeles, 542 miles. This will comprise the longest stretch of continuous automatic electric block signals in the world.

A bill recently introduced in the Canadian Parliament provides for the control of telephone rates by the Dominion Railway Commission.

June Meeting of the New England Section of the Illuminating Engineering Society

THE last regular meeting for the season of the New England section of the Illuminating Engineering Society, held in Boston, on Tuesday evening, June 26, was a question box meeting, the questions for discussion having been submitted by the members and printed previously. A large number of questions were presented, but only a few could be taken up in the limited time.

President L. B. Marks spoke on some particular applications of the semi-concealed methods of lighting, and described in detail the lighting of a church where a very good illumination was obtained at a reasonable cost. Dr. Louis Bell commented on the colours of some of the common forms of illuminants, and also mentioned some of the commercial difficulties in obtaining good illumination. Mr. Cummings, of the Boston Consolidated Gas Company, spoke on the distribution curves of various lamps and the value of reflectors from a photometric point of view. Mr. Allen, of the General Electric Company, gave a brief description of some diffusing devices which are being used with good results in store and factory lighting.

The subject of concealed lighting in halls, auditoriums, and the like, was discussed freely by Messrs. Marks, Gardner, Cummings, Robinson, and others.

Anuual Convention of the American Street and Interurban Railway Asseciation

A BULLETIN recently sent out by B. V. Swenson, secretary of the American Street and Interurban Railway Association, gives some additional particulars of the convention to be held at Columbus, Ohio, during October 15 to 19.

Columbus is on the main lines of the Pennsylvania and Big Four systems, and eighteen steam railroads radiate from the city. New York, Philadelphia, Savannah, Memphis, St. Louis, Milwaukee, Toronto and Albany are all within a radius of 500 miles, so that representatives from a large area may readily reach Columbus on fast trains by a night's journey.

Some doubts have been expressed as to the adequacy of the hotel facilities in the city, but investigation has shown that there is no reason for doubt on that score. Four of the hotels, the Chittenden, Neil, Hartman, and Southern, all under one management, have guaranteed 600 rooms, and as many more will be available in a number of smaller hotels.

The association headquarters will be at the Fair Grounds, and no one hotel will be a strictly headquarters hotel. However, the Southern will probably be the general meeting place in the evenings, and it is there that the annual banquet will be held. It is planned to make the Hartman Hotel the headquarters for the ladies who attend the convention.

Hotel accommodations may be reserved by writing Benj. H. Harmon, secretary convention committee, Columbus Board of Trade.

A committee from the Manufacturers' Association has already visited Columbus, and arrangements are going rapidly forward for the largest and most comprehensive exhibit of street railway apparatus and appliances which has ever been gathered together in one place. The exhibit at Philadelphia was considered the best which had been held up to that time. The available floor space at the Fair Grounds in Columbus is nearly double that of last year, and the plans for the Columbus exhibit are much more elaborate than were those of 1905.

Electric Traction on the New York, New Haven & Hartford Railroad

IT is probable that the first single-phase electric train will run on the New York, New Haven & Hartford Railroad between New York City and Stamford, Conn., before the summer is over. The latest reports from Coscob, where the electric power station is now being erected by Westinghouse, Church, Kerr & Co., who have charge of the construction of that building, are to the effect that everything is now about ready for the reception of the first installment of electrical machinery. The latter is being pushed at the Westinghouse works in East Pittsburg with the utmost expedition, and the first generator is already in the testing department.

The initial installation of apparatus will have a capacity of 13,000 H. P., consisting of Westinghouse-Parsons steam turbines and Westinghouse alternating-current, single-phase generators. Of the thirty-five locomotives, which will be operated on the road to begin with, the first are now undergoing practical tests on the Westinghouse inter-works railway at East Pittsburg.

The Utilization of Water Powers of Low Head in the Central West

By DUGALD C. JACKSON

A Paper Read at the Milwaukee Convention of the American Institute of Electrical Engineers

FIG. 1.—VIEW OF THE UPPER DAM WHILE THE CENTRAL PLANT OF THE JANESVILLE ELECTRIC COMPANY WAS BEING CONSTRUCTED. THIS IS ONE OF THREE PLANTS OWNED BY THE COMPANY, TWO BEING USED FOR NORMAL SERVICE AND ONE FOR PEAK LOADS

THE necessity for the utmost reduction in the cost of their product is being pressed more determinedly upon the electric generating companies located in the smaller cities of the Central West as the use of the electric current becomes more generalized. The extension and generalization of the use of current also goes hand in hand with, and is encouraged by, reduction in the cost of the plant output, since a generating company may obviously increase its sales at a rapidly accelerating rate as the price of its product falls.

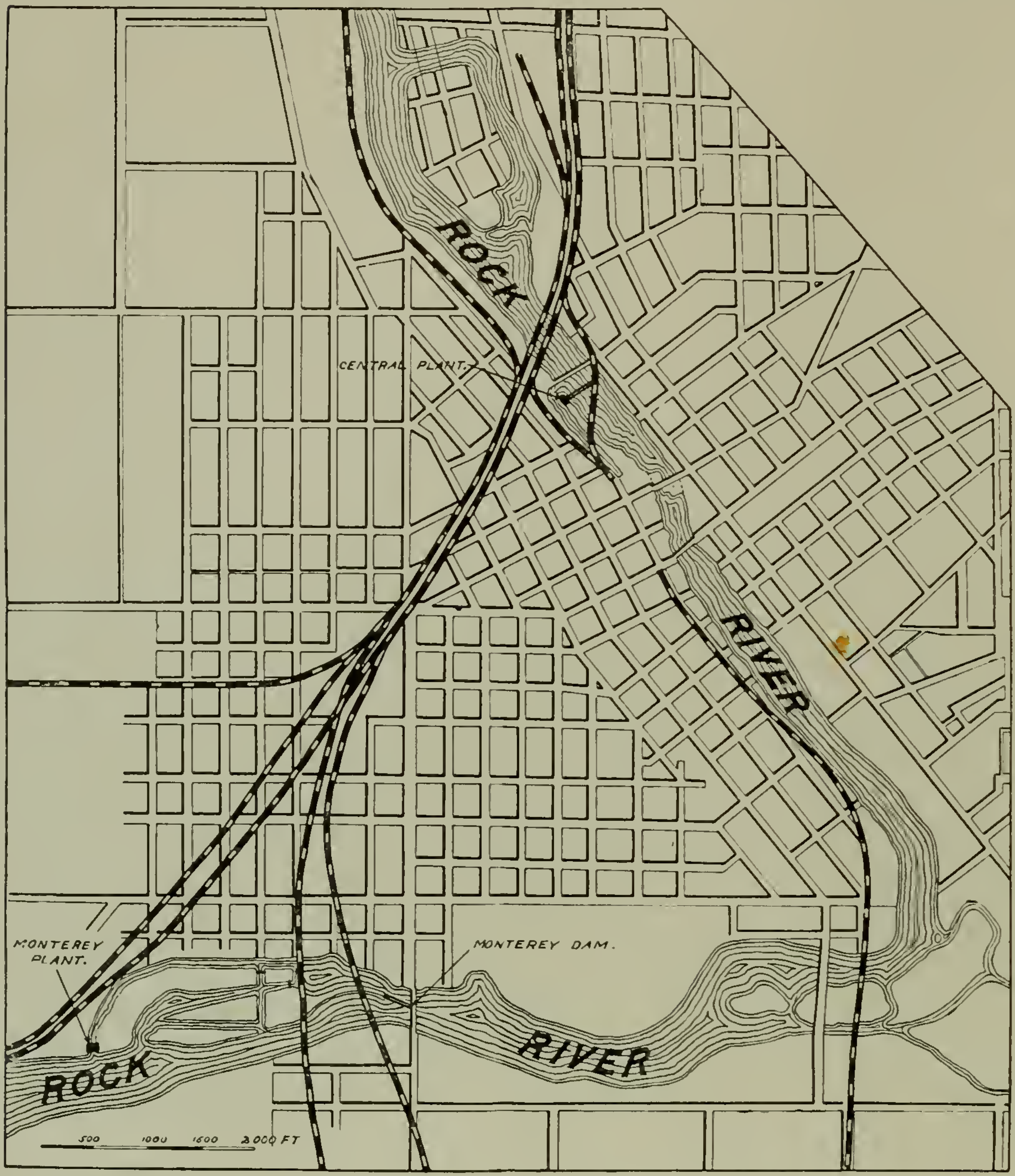
It is well known to engineers familiar with the conditions of the Central West that the electric plants of the cities of medium and smaller size have, until recent years, been of characteristically unsubstantial construction, and the operating expenses have been proportionately high.

The author proposes to tell briefly something of the way in which the electric light company in one of these smaller cities, namely, Janesville, Wis., a city of about 15,000 inhabitants, has improved its condition by getting away from the old-time uneconomical plant to a plant of modern construction which is substantial, and is capable of producing current with so much economy that the use of the product has extended enormously during the last three years. The situation in Janesville is taken for the subject of this paper because of the unusual fact that the company has been able to utilize three separate water powers, two of which are used for continuous service, and the third for peak-load service.

Three or four years ago the Janesville Electric Company was operating a power house in the heart of the city, and was there utilizing a small amount of water power in conjunction with a considerable amount of steam power, the latter being generated under conditions of much inconvenience and lack of economy. The company also owned a small water power some miles from the city, and it utilized this for operating a synchronous motor in the city station, and the like.

The company came into hands with financial strength and keen foresight, and it obtained nearly exclusive water rights at two dams on the Rock River, located within the limits of the city of Janesville.

An examination of Map 1 shows that the Rock River flows from the north into the city of Janesville, makes an easy easterly turn, and then



MAP I. SHOWING THE COURSE OF ROCK RIVER THROUGH THE CITY OF JANESVILLE

swings sharply toward the west before it leaves the limits of the city. As it makes its turn through the city, it also makes a rapid drop in level.

At a point a few blocks from the business center of the city, there is an old timber dam which has long been used to develop water power that was originally utilized for running a grist mill and other like purposes, a canal of some length having been extended along the margin of the river through a portion of the city. The electric company obtained water rights for the greater portion of the power on this site, and also the site of the old grist mill upon which the company has erected a modern fireproof power house. This is the Central plant named on the map.

Just southwest of the point where the river turns sharply westward before leaving the limits of the city, is another old timber dam, which has been in existence many years. It formerly supplied power to a woolen mill, and of recent years also furnished the power for operating a cotton mill; but the cotton mill was closed down, and the Janesville Electric Company was enabled to obtain its site with power plant and the greater portion of the water rights at this dam. This is the Monterey site, which is marked upon the map.

The third water power is a small power about 12 miles from Janesville, the water rights of which are owned exclusively by the company, this is the Fulton site, which may be seen on Map No. 2.

The plants at these three power sites will be designated respectively, as the Central plant, the Monterey plant, and the Fulton plant.

Upon securing the water rights and the mill site where the Central plant now stands, the Janesville company placed the development of a suitable electrical generating plant in the hands of engineers. The condition of the site at that time is indicated in Fig. 4. The old mill was torn down, a suitable forebay excavated, reinforced concrete penstocks erected, suitable water-wheels installed, and measuring gates erected at the entrance to the forebay.

The measuring gates are large, movable gates which are required because the electric company does not own quite all of the water rights. They were installed under the direction of the county court for the purpose of properly dividing the water between the owners in accordance with their proportionate ownership. The condition of the site while this work was going on is indicated by the illustration in Fig. 1. Fig. 5 shows the site after the completion of the power house.

In passing, it may be remarked that the concrete work for the penstocks was prosecuted in midwinter with the temperature at times 12 to 16 degrees F. below zero, but careful precautions were taken and the concrete has proved exceptionally free from defects.

The dam at the Central plant affords a head of 8.5 feet at normal water, which is somewhat reduced in the case of high flood waters on account of the effect of back water. The Rock River rises in a marshy region in Central Wisconsin, and has a drainage area of approximately 3250 square miles. It is a river of reasonably equable flow, though it is subject to quite low water in the late summer, and rather high water in the early spring. Ordinarily it has a very satisfactory flow during those months that afford the greatest daily load for the electric light company.

The water-wheel equipment installed at this point consists of six wheels, four rated at 148 H. P. each, and two rated at 100 H. P. each, the four being arranged to drive upon a main horizontal shaft, while the two drive an independent shaft. The latter two are wheels which were already owned by the company when this plant was developed, and they were temporarily installed for use until the demand for power shall become sufficiently great to make it worth while to replace them by wheels corresponding to the other four.

The company had been operating a rather mixed lot of circuits, including Edison direct-current three-wire system, 110 volts on a side, for incandescent lamp lighting, with 220-volt direct-current motors between the outside wires; 500-volt railway circuits; alternating-current incandescent electric lighting circuits; direct-current series arc lighting circuits, and circuits to polyphase alternating-current motors. This mixed system had partially come about through the merging of two companies a considerable number of years ago, and partially through the gradual development of the plant toward an alternating-current plant.

When the Central plant was constructed and the old plant in the heart of the city abandoned, it was decided that the better economy lay in preserving the mixed system for the present, since considerable of the machinery was in very good shape and a good many direct-current motors were in use. Consequently the company still maintains the direct-current three-wire system, the 500-volt electric railway circuits, and its alternating-current circuits for incandescent lighting and motors. It has changed its arc light system so as to use alternating-current series arc lamps operating from Thomson tub transformers.

Such of the electric generators of the old plant as were modern and in good operating condition were moved to the new Central plant. These included one 500-volt generator for the railway load, two 110-volt generators for direct-current lighting and power load, and a 250-volt direct-current machine, which, with other purchased machines, serve a double purpose, namely, either to operate between the outside wires of the direct-current three-wire system, the 110-volt machines taking care of any lack of balance, or, connected in series with each other, to operate with the 500-volt generator in connection with the railway load. Additional 250-volt direct-current machines have since been purchased and installed for a like purpose.

A synchronous three-phase alternator of 6600 volts pressure had been in use as a motor driving a jack-shaft in the old city station, receiving power from the Fulton plant, for the purpose of aiding the old city station in coping with its peak-loads. This machine of 85-KW. capacity and another three-phase alternator of 150-KW. capacity were installed in the Central plant, and these are connected to the switchboard in such a manner that they may be used as synchronous motors to receive power from either or both of the other generating plants, thus aiding to drive the generators in the central plant.

They may also be used as generators, being driven by the shaft of the Central plant, and thus deliver power to the polyphase alternating-current circuits and tub transformers. The latter, four in number, are located in this plant and are divided two and two between two phases of the three-phase circuits, while the third phase is connected to the alternating-current incandescent lighting circuits. The three phases are utilized to operate polyphase motors, of which there are several of considerable capacity.

The power house at the central station stands on made ground between the old power canal and the river bank. The foundations are supported on piles. When it came to building the house it was found that a concrete block building could be put up more economically under the particular circumstances than a building of brick, and the block construction was therefore chosen, the type of blocks being carefully selected so as to afford a satisfactory appearance. Artificial rock-faced blocks were used in the exterior lower courses and the pilasters of the building, while blocks with imitation bush-hammered faces were used for the remainder of the exterior of the building. All the blocks are smooth on the faces exposed in the interior of the building. The roof-trusses are of steel, and the roof is covered with fireproof roofing. An exterior view of the power house is given in Fig. 5. The corrugated-iron extension to be seen in the photograph running toward the observer composes a covering for the wheel settings.

The equipment in use in the power house includes two steam engines and a boiler which were installed for reserve purposes. The boiler is of the water-tube type, purchased at the time of the erection of the power house, and the two engines, respectively a Corliss engine of 300 H. P., and a high-speed engine of 150 H. P., were moved from the old city power house. The steam plant is arranged so that the Corliss engine may be connected by friction-clutch to the water-wheel shaft so that the steam and water power can work together.

As the generators in this station are relatively small, they are all belted, and the 110-volt machines are operated in pairs by tandem belts to save space. The low head makes the use of vertical water-wheels necessary, and bevel gears are used for transmitting the power to the horizontal shaft.

Some engineers who have not had experience in the operation of such plants undoubtedly may criticize the introduction of the small belted units into this plant and the use of tandem belts; but experience shows that it is satisfactory and reliable, and there is no doubt that it has cost the company less per annum through operating these machines than the additional annual charge which would have been imposed by selling these

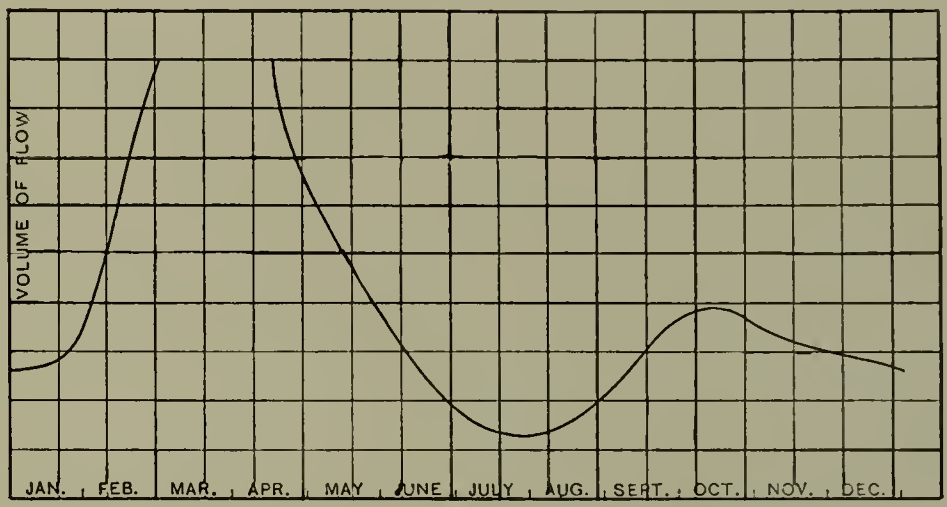


FIG. 2.—CURVES SHOWING GENERAL CHARACTER OF VARIATION OF STAGES OF WATER DURING THE YEAR

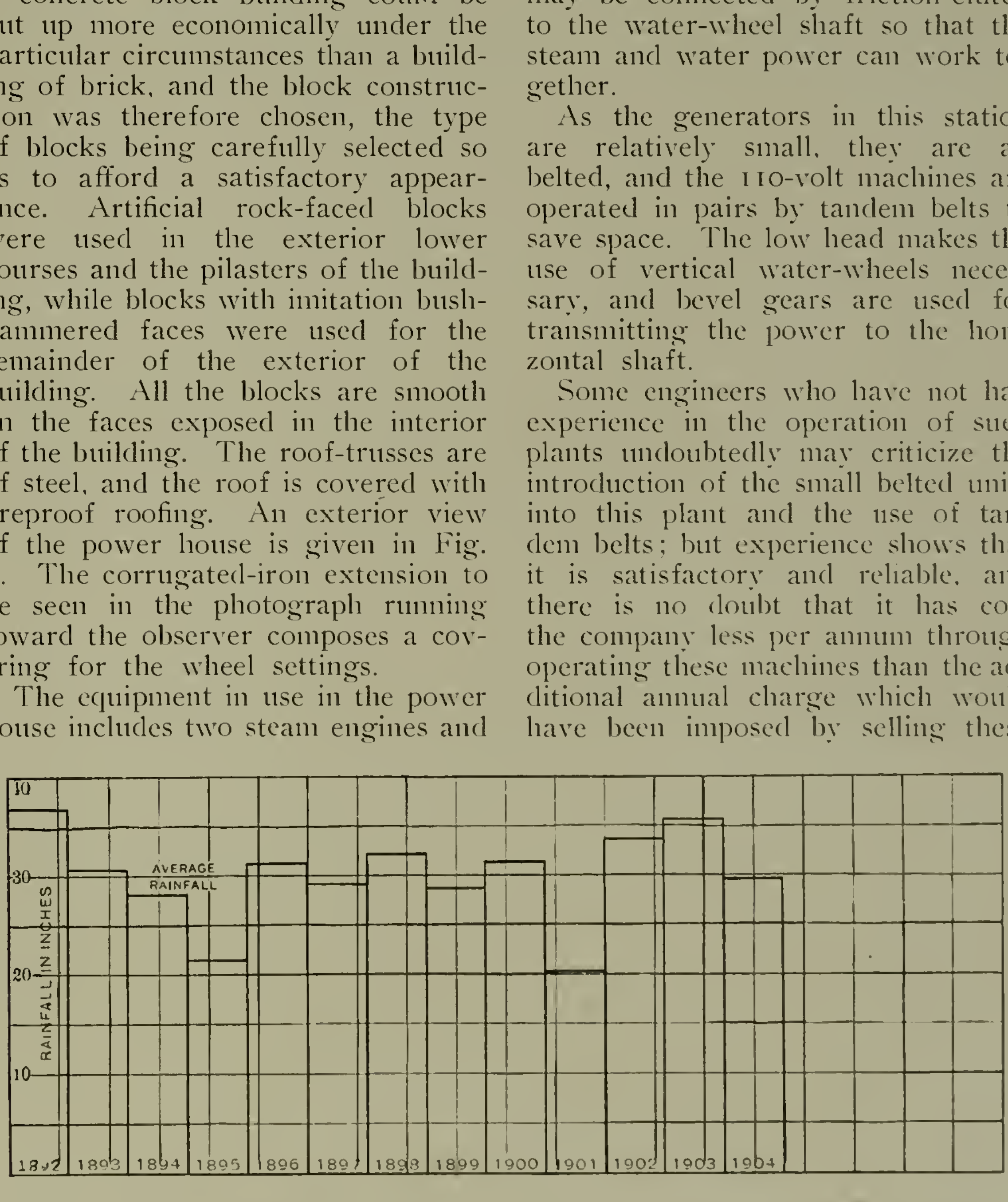


FIG. 3.—ANNUAL RAINFALL ON DRAINAGE AREA OF ROCK RIVER, AVERAGED FROM RECORDS TAKEN AT ELEVEN STATIONS

FIG. 4.—VIEW OF THE UPPER DAM AND GRIST MILL AT THE SITE OF THE PRESENT CENTRAL PLANT

machines at second hand and purchasing others of uniform type. The use of direct-connected machines is not practicable under the conditions of the plant.

The Monterey plant, which is on the Rock River about 2 miles south of the Central plant, is now operated from the old water-wheels of the cotton mill, which are mounted in an unsatisfactory manner, and this summer will see the water-wheel development at this point extended so that the old wheels may be ultimately replaced and the full power of the site taken advantage of.

There is also located at this point an admirable Corliss engine of 350 H. P., which was part of the cotton mill equipment, and which is still maintained by the electric company as part of its steam reserve. One 275-KW., three-phase generator is now temporarily installed in this plant, driven by the old wheels of the cotton mill, of which there are four, three being rated at 100 H. P. each, and one being rated at 50 H. P.

Additional generating capacity will be added this summer after new concrete penstocks have been put in, and two new water-wheels of 250 H. P. each have been installed therein. The old equipment will probably be maintained for another year to operate in conjunction with the new, after which it will be replaced by larger and better apparatus.

The generating capacity of this plant may be utilized in co-operation with the Central plant, either by operating a synchronous motor at the Central plant to aid in driving the direct-current machinery, or by delivering the alternating current to the alternating-current distributing system through the Central plant switchboard or both.

The head which the Monterey dam affords at normal water is approximately $9\frac{1}{2}$ feet, which is somewhat reduced at times of excessively high water. A fair amount of storage exists in the pond above the dam at each of the Central and Monterey plants, so that advantageous use may be made of the water for the variable load of the lighting company.

The Fulton plant is about 12 miles northerly from Janesville. It is located on the Yahara River, a stream colloquially known as the Catfish, which is the outlet of a string of lakes which have surface area of about 60 square miles. The stream also has some sources of supply from branch streams entering below the outlet from the lakes. The total drainage area covers approximately 510 square miles above Fulton.

The head afforded by the dam is 14 feet, and the pond above the dam affords considerable storage capacity. This plant is therefore used only for peak-loads, and is consequently operated only a few hours each day, under ordinary conditions. The plant has been in its present condition for a number of years. Its equipment includes three 75-H. P. water-wheels and a 150-KW. three-phase generator. The water-wheels are vertical wheels geared to a horizontal shaft.

A small generator is also installed in this power house for the purpose of contributing to the lighting of the town of Edgerton, which may be seen on Map 2. This generator is supplied by the owner of the electrical supply for the village of Edgerton, who owns a water power site of very low head on the Rock River at a point marked Indian Ford, which can be seen on the map, and who found it desirable to buy some of his power from the Fulton plant of the Janesville company on account of the insufficiency of the Indian Ford plant.

This Fulton plant has a transmission line of 6800 volts pressure. The city distribution circuits on the alternating-current system are of 3200 volts pressure. The alternating-current machines in the Monterey and

FIG. 5.—THE UPPER DAM AND CENTRAL PLANT OF THE JANESVILLE ELECTRIC COMPANY AFTER COMPLETION

Central plants are of 2200 volts pressure, with the exception of one old synchronous machine which operates at 6600 volts.

Transformers suitably located with respect to this 6600-volt machine in the Central plant make it possible to use it in connection with the 2200-volt lines as motor or generator, or to receive power from the 6600-volt line from Fulton. The same transformers also provide means by which the 6600-volt line may feed directly into the 2200-volt distribution circuits.

It will thus be seen that the three plants may work together. They ordinarily operate as substantially one generating unit by being associated during peak-loads.

Under usual conditions of operating, the two alternating machines in the Central plant are utilized as motors in driving the direct-current machines, deriving their power from the other two stations, and the alternating-current distribution lines of the system are supplied by current from the other two plants through the Central plant switchboard. The arrangement of the switchboard is simple, but it affords the possibility of operating the plants in any combination on the distribution circuits, either with each other or singly, as the storage of water or other conditions may make desirable. A thoroughly efficient combination of the three plants is accomplished, and the company is remarkably well fortified against interruptions of service.

The synchronous alternating-current machine, being operated either as a generator of a motor without any changes in its connections, is a device of great convenience in a system like that of the Janesville Electric Company. It also adds materially to the reserve generating capacity of the plant so that some economy of space results, and some driving gear and machinery are dispensed with.

Map 3 shows that the drainage area of the Rock River above Janesville includes nearly the whole of the counties of Dane, Jefferson and Dodge, and considerable portions of the counties of Rock, Waukesha, Washington and Fond du Lac, most of which are notably excellent and well cultivated farm and dairy counties. This gives a reasonable basis for expecting fairly stable conditions of the water power, so that the future power may be reasonably estimated from the records of the past.

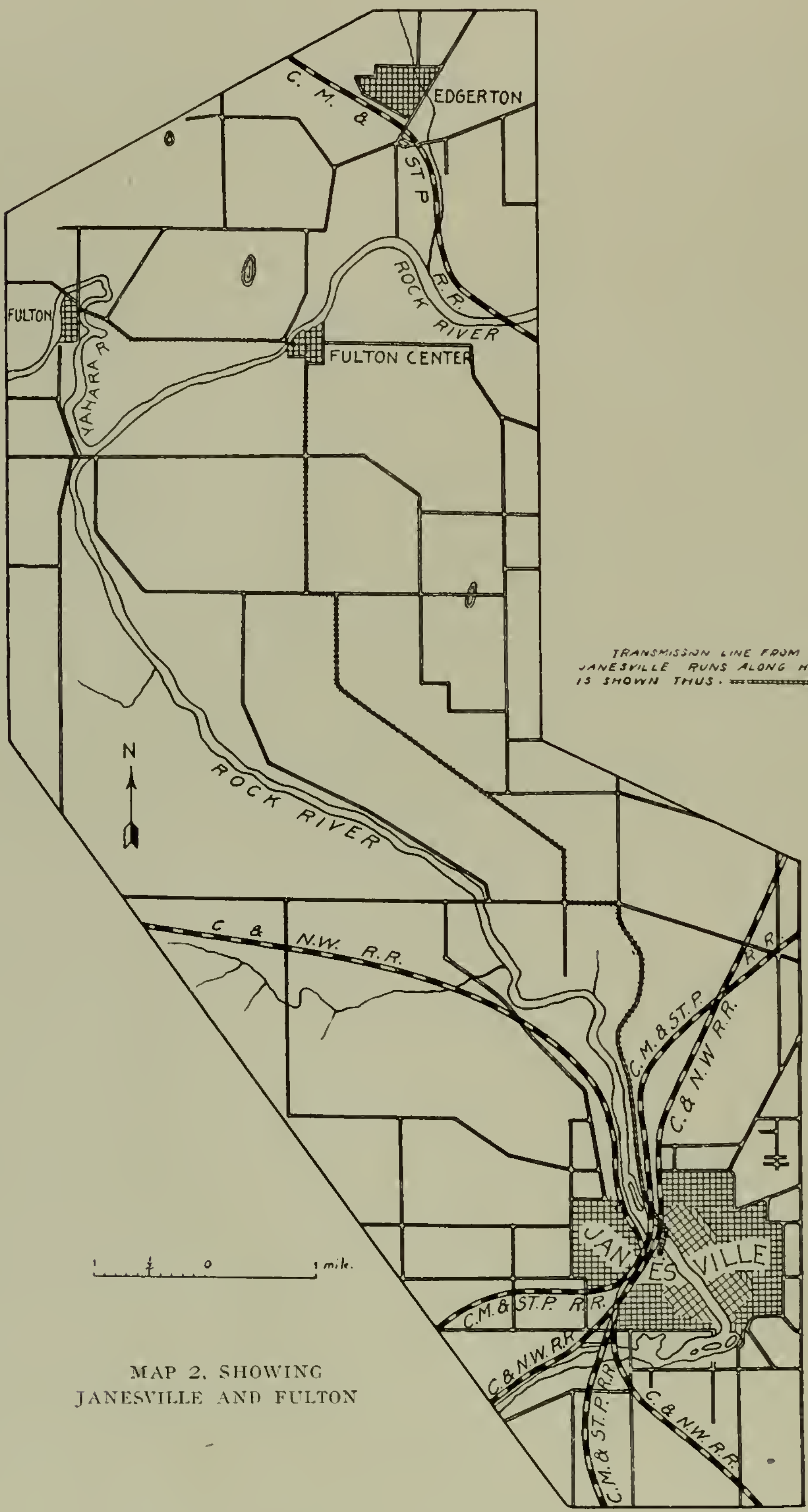
The map illustrates in a rather graphic manner the general characteristics of the drainage area with its numerous lakes and streams. The river has an average slope of about 1.2 feet to the mile and runs through a country of loamy soil which was once covered by extensive forests that have now disappeared, and the land is well developed for agricultural purposes. The area lies in the region of glacial drift which accounts for numerous lakes and marshes and their tributary small streams.

The extreme source of the river is the extended Horicon marsh, once a large lake, but now partially drained. The river is fed as it flows southward by numerous streams, which themselves originate usually in small lakes and marshes, and it passes through Lake Koshkonong, widely famous as a feeding ground for canvas-back ducks during their migrations.

At a point about a dozen miles from Janesville, the river receives the waters of the Yahara which discharge from the Four Lakes of Madison and from the various small streams and marshes. The Fulton plant is located on the Yahara River above its junction with the Rock River.

A peculiarity of the under soil of the area robs the river at Janesville of that uniformity of flow which might be expected from the considerable area of lakes and marshes which contribute to the waters of the river. A substratum of sand and gravel or sandy nature lies beneath the surface soil and carries a heavy flow of underground water throughout the year. It may be reasonably supposed that a goodly proportion of the total waters discharged from the area are found in this underground flow, and that the apparent river flow suffers most of the fluctuations following precipitation, thus causing an increased ratio between the waters discharged by the river in the high and low-water months of each year.

The gaugings of the Rock River do not extend as far into the past as could be wished, and those records that exist are meager and were mostly taken at stations below Janesville, but the drainage area extending to one of these stations is of the same general charcter as the area above Janesville, and estimates of the Janesville flow must be based on those gaugings.



MAP 2. SHOWING JANESVILLE AND FULTON

It seems on this basis that the Janesville Electric Company, after raising its dam at Fulton a little, can afford to install water-wheels with a capacity as a probable ultimate limit of 2500 H. P. to meet the requirements of increasing loads. Four-fifths of this capacity would be about equally divided between the Central and Monterey plants, and the remainder would be located at Fulton. This equipment would be made with the expectation of taking the utmost advantage of the storage ponds at the dams for the purpose of helping over peak-loads which demand more power than the normal flow of the river at the time, but do not exceed the capacity of the water-wheel installation.

When the load has grown to make this water-wheel capacity needed, it may be expected to operate as much as 500 or 600 H. P. of the steam reserve for several hours per day during the months of November and December. Small amounts of steam power will likely be required for short times during some days in other months,—such as the months of August and September, when the flow of the river is ordinarily at a minimum, or the months of March or April for the days of excessively high water accompanied by decreased head caused by back water. Fortunately the flow curve of the river has its lowest position in months when experience shows that the demand for electrical energy is likely to be relatively small, and the total use of steam power for the year may be decidedly small.

Fig. 2 shows the general slope of the flow curve of the river during a year. This is merely typical and is introduced to indicate the months of the year when the low and high water may be expected. The actual flow curve of the river has many sinuosities not shown.

Rainfall records taken within the drainage area of the Rock River do not extend far enough into past years to be very serviceable as an aid to estimating the stability of the water power considered for a cycle of years, but Fig. 3 shows the annual rainfall averaged for eleven stations on the drainage area and extending back for fourteen years.

Fig. 6 shows the annual rainfall as observed for fifty years past at the cities of Beloit and Milwaukee. Beloit is located on the Rock River about 14 miles below Janesville. Milwaukee is located directly on the shore of Lake Michigan, about 80 miles east of Janesville and a few miles east of the eastern boundary of the Rock River watershed. The effect of the environment of Milwaukee makes its rainfall records of little use for consideration in connection with the Rock River area.

The Janesville Electric Company has made remarkable progress under efficient management. During the year 1905, the electrical output aggregated nearly 2,000,000 KW.-hours, which were absorbed by a city of 15,000 inhabitants. The corresponding output for the year 1903 was a little more than half as great.

During the year 1905, which was the first year in which the full advantage of the water power at the Central plant was available, there were only five days during which the steam reserve was operated on account of lack of water power; these were the first five days of April, when the water reached a height greater than had been recorded in the previous twenty years.

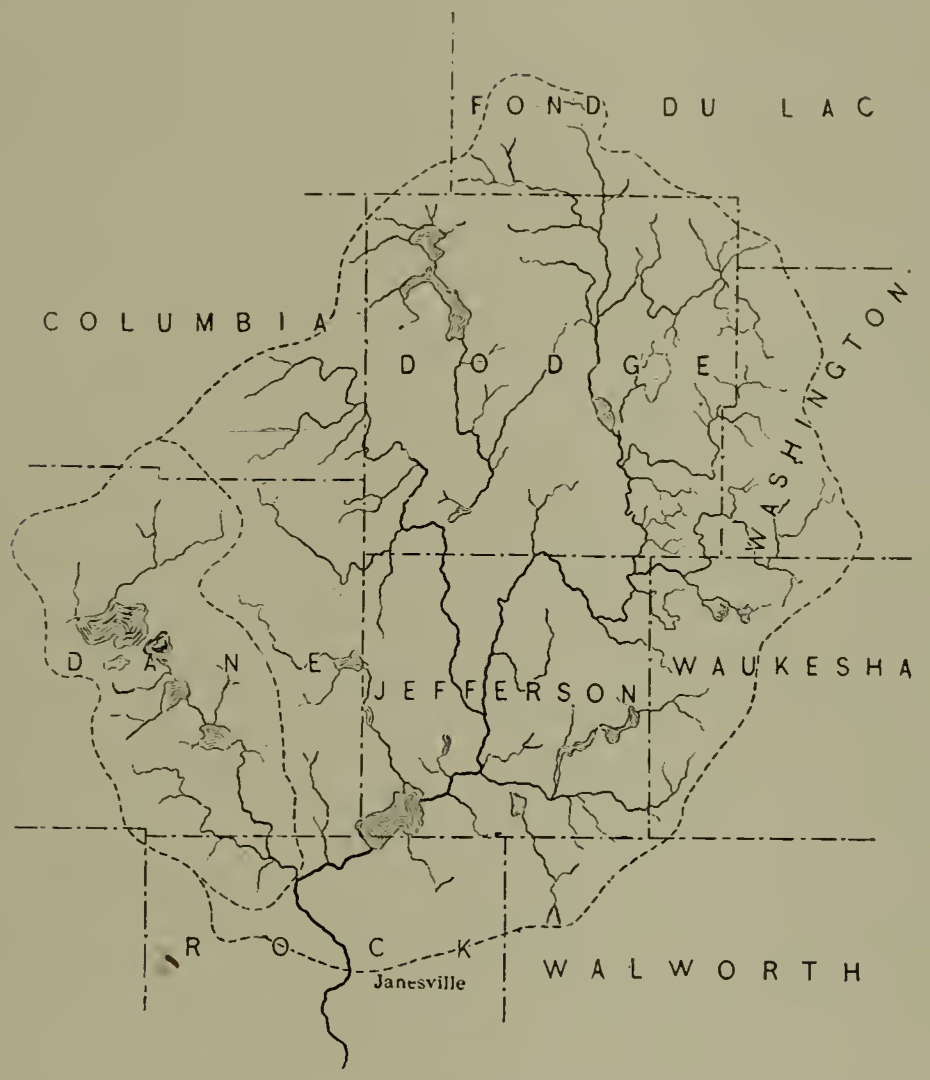
During these days, three-fourths of the Fulton output was sent to Edgerton because the power of the low-head Indian Ford dam was wiped out by the high water, and the Edgerton supply had to be purchased from the Fulton plant, though ordinarily the Fulton plant only furnishes power to Edgerton in the winter time, to help out with the peak-load between five and six o'clock.

During the early part of the year 1905, a steam-driven generator was operated in connection with the street railway service, but this was due to the fact that the generating capacity had not been fully installed. During the very last part of the year, the same condition arose on account of the growth of the output, and a steam-driven generator was connected on the street railway service nearly every evening for a short time, but this condition will be helped after the Monterey improvement is completed this summer.

The saving in the cost of fuel over operating a steam-driven station is sufficient of itself to make a good return for the extra cost of the power development.

The plants are also fairly economical from the standpoint of the labour required, considering the division between three cities. The Fulton plant, which operates under peak-loads, is operated and cared for by one man who lives in the vicinity of the plant. When important repairs are required, men are sent from Janesville, but otherwise this one man furnishes all required labour.

The Monterey plant is operated for the 24 hours by two men, one man on each 12-hour shift. The Central plant is operated by four men, two men on each 12-hour shift. Thus the three stations require a total of seven operating attendants on the pay roll, whose labour is distributed during the 24 hours. These men have the care of substantially 1200 KW. in generating capacity beside tub transformers, water-wheels, steam reserves, and the like. If the plants were combined in a single steam-driven station furnishing the same variety of service, such a station would probably require an aggregate of more than seven operating attendents on the pay roll.



MAP 3. SHOWING THE DRAINAGE AREA OF ROCK RIVER. IT RISES IN A MARSHY REGION IN CENTRAL WISCONSIN AND DRAINS AN AREA OF ABOUT 3250 SQUARE MILES

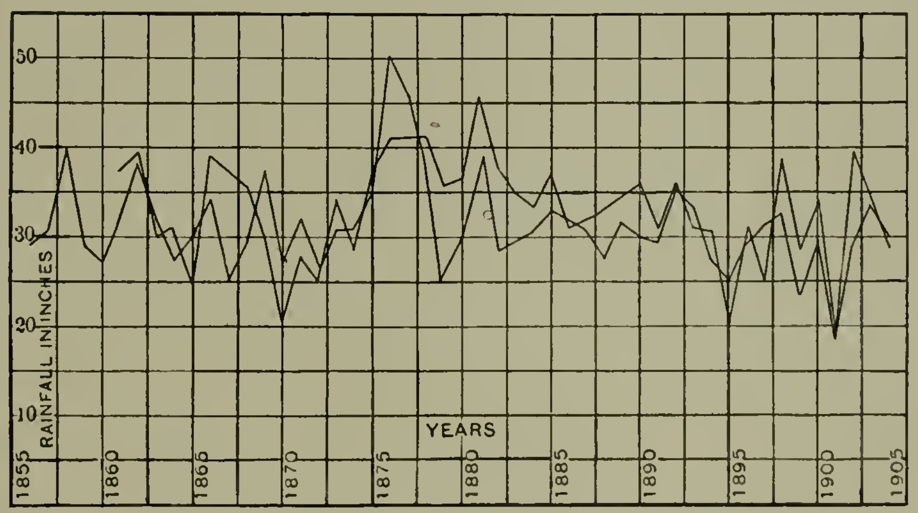


FIG. 6.—RECORDS OF RAINFALL AT BELOIT AND MILWAUKEE. THE MILWAUKEE RECORD BEGINS FURTHER AT THE LEFT

Delegates to the Saratoga convention of the Street Railway Association of the State of New York, visited Schenectady at the invitation of the General Electric and American Locomotive Companies. The party included about fifty members of the association and was in charge of E. F. Peck, manager of the Schenectady Railway Company, and chairman of the entertainment committee, and other officials. Special cars, furnished by the local railway company, brought the guests to the city, where they were received by officials of the American Locomotive Company. After viewing the works, the party proceeded to the factories of the General Electric Company where an informal lunch was served in the new firemen's headquarters building. The reception committee at the works included J. G. Barry, C. P. Haskins, G. H. Hill, E. D. Priest, Theodore Beran, manager of the New York office; F. H. Gale and others.

Protection From Lightning During 1905

A REPORT READ AT THE ATLANTIC CITY CONVENTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

According to the report on protection from lightning during the year 1905, presented at the Atlantic City Convention of the National Electric Light Association by a committee consisting of Alex. Dow, C. A. Honnold, and R. A. Stewart, the effects of lightning and static disturbances depend so much on local conditions and are felt at such rare intervals that it is not possible to formulate any general principles from the study of the experiences of a single lighting and power system.

If, however, the experiences of a large number of stations, located in all sections of the United States, are tabulated, these statistics should be very helpful in deciding on what methods of protection should be adopted in any particular case. In order to obtain such statistics the committee sent to each of the companies in the National Electric Light Association a circular letter asking for information in regard to lightning troubles during 1905.

The replies were classed under two general heads:—Stations operating under 10,000 volts, and stations having transmission lines of 10,000 volts or over. This division is natural, for very few, except the stations operating at very high voltage, have long transmission lines, and the methods of protecting transmission lines are different from those used in distribution lines.

Each one of these two classes was divided into three, as follows:—

A. Companies suffering no damage.

B. Companies whose losses were confined to lightning arresters and meters.

C. Companies suffering more serious losses. All who had lost transformers or other expensive apparatus were included under this head.

The table on this page gives the results of the inquiry.

In analyzing these results special attention is called to the following points:—

Freedom from Trouble.—Two-thirds of the companies have been practically free from trouble. This proportion holds in the high-tension as well as the low-tension plants. In the plants of large kilowatt capacity this is apparently reversed; but when it is considered that one transformer was lost for every 1850 kilowatts station capacity under 10,000 volts and one for every 5400 kilowatts capacity over 10,000 volts, it is surprising that more of the large plants are not in the troubled class "C."

The money-value of property de-

STATISTICS FROM REPORTS ON LIGHTNING TROUBLES DURING 1905

	—Under 10,000 Volts—			—Over 10,000 Volts—			
	A	B	C	A	B	C	Total
Total companies reporting	40	19	25	15	3	11	113
Total kw capacity of stations	33,230	70,200	25,775	50,825	4985	84,680	269,695
Average kw capacity per company	830	3.690	1030	3390	1660	7700	2380
Stations under 200-kw	12	2	7	0	0	0	21
" 200 to 490-kw	9	3	3	4	0	1	20
" 500 to 990-kw	7	3	9	2	1	1	23
Stations 1000 to 1490-kw	4	2	0	2	0	1	9
" 1500 to 1990-kw	4	1	1	0	0	1	7
" 2000 to 2990-kw	2	3	2	0	2	0	9
" 3000 to 4990-kw	1	2	2	4	0	2	11
" 5000-kw and over	1	3	1	3	0	5	13
Distribution voltage							
110 to 250 volts	9	2	0	0	0	0	11
500 to 700 volts	8	6	10	4	3	7	38
1000 to 1200 volts	9	1	6	1	0	1	18
2000 to 2500 volts	21	16	19	14	3	9	82
4000 to 4600 volts	1	0	0	0	0	0	1
Transmission voltage							
3500 to 4600 volts	0	2	2	..	..	..	4
5500 volts	1	0	0	..	..	..	1
6600 volts	3	3	3	..	..	..	9
10,000 to 13,000 volts	..	..	..	9	3	5	17
20,000 to 24,000 volts	..	..	..	4	0	3	7
30,000 to 36,000 volts	..	..	..	2	0	1	3
40,000 to 45.000 volts	..	..	..	0	0	1	1
55,000 volts	0	..		0	0	1	1
Length of transmission lines—miles	28	117	35	438	64	614	1296
Under 60 cycles	0	2	0	1	0	2	5
60 cycles	25	15	16	14	3	9	82
125 to 140 cycles	7	0	9	0	0	0	16
Single-phase	11	2	7	0	0	0	20
Two-phase	9	4	7	3	1	0	24
Three-phase	12	11	11	12	2	11	59
Direct-current service only	8	2	0	0	0	0	10
Companies using G. E. arresters	22	16	17	10	1	11	77
Companies using Westinghouse arresters	14	7	17	6	2	5	51
Companies using Stanley arresters	4	4	4	0	0	0	12
Companies using Garton-Daniels arresters	3	4	5	0	1	0	13
Companies using miscellaneous arresters	2	1	0	0	0	0	3
Companies using choke coils	8	7	10	9	2	9	45
Companies using no choke coils	14	8	10	4	0	2	38
Companies using overhead ground wires	1	3	0	3	1	2	10
Companies using no overhead ground wires	35	14	24	11	1	9	94
Apparatus injured during 1905							
Lightning arresters	0	45	38	0	4	20	107
Transformers	0	0	70	0	0	26	96
Meters	0	28	38	0	0	0	66
Armatures	0	0	5	0	0	3	8
Oil switches	0	0	2	0	0	4	6
Shut-downs due to too violent discharges or to arc holding on in arresters? Yes	1	11	6	3	1	7	29
No	39	8	18	12	2	4	83
Number of times	3	21	20	8	4	30	86
Were there damages therefrom? Yes	0	13	13	1	2	7	36
No	40	7	11	14	1	4	77
Were apparatus or lines burned out or grounded due to failure of arresters to discharge? Yes	2	7	12	2	3	9	35
No	38	9	10	13	0	2	72
Number of times	4	13	28	2	6	37	90
Were there damages therefrom? Yes	0	6	18	2	2	10	38
No	39	9	7	13	1	1	70
Shut-downs due to discharges between line wires Yes	1	0	2	2	0	2	7
No	39	15	21	14	3	7	99
Number of times	1	0	9	2	0	2	14
Have poles been split or insulators been broken by lightning discharges? Yes	2	4	7	6	2	5	26
No	31	11	15	7	1	6	71
Number of poles split	3	13	19	30	4	25	94
Number of insulators broken	..	..	4	..	..	18	22
Companies reporting that damages are most frequently caused by severe storms	8	12	20	6	3	8	57
Companies reporting that damages are most frequently caused by mild storms and static charges	1	1	1	1	1	1	6
Are lines seriously affected at a distance from the center of a storm? Yes	0	3	1	1	0	2	7
No	15	13	13	11	3	8	63
Shut-downs due to damages caused by sudden changes of load or short-circuits? Yes	9	5	13	4	0	5	36
No	18	11	10	9	3	5	56
Number of times	19	19	37	14	0	89	178
Were the damages serious? Yes	0	0	4	0	0	1	5
No	27	15	16	13	3	8	82
Is your lightning protection satisfactory? Yes	20	8	6	7	1	1	43
No	9	10	16	6	2	9	52
Companies advising the use of more arresters	7	2	10	3	1	1	24

stroyed by lightning is extremely small compared with the value of the plants, for, even when transformers are burned out, they can be repaired at moderate expense. The principal loss is due to interruption of service.

The freedom from trouble is due largely to the increased use of lightning arresters and largely to the high grade of insulation in modern transformers and generators. Every year, as old transformers are replaced by newer types and as defective lightning arresters are replaced by more efficient types properly located in the system, the troubles should diminish.

Type of the Average Station.—The standard station at the present time runs at 2300 volts, 60 cycles, three-phase. There is a large number of two-phase stations operating below 10,000 volts, but above 10,000 volts practically all plants are three-phase. The average size of stations below 10,000 volts is 1540 kilowatts, and of stations of 10,000 volts and over is 4840 kilowatts.

Arresters Injured.—There has been quite a little trouble with burned-out graphite resistances in lightning arresters. This resistance is a very variable quantity, being greatly affected by electric discharges. Carborundum and other mixtures are used in the latest types, and resistances of these materials seem to be constant and do not fly to pieces as the graphite rods do.

The wire resistances in the Westinghouse low-equivalent arresters have also burned out in several cases. Objection is made to the wire resistance that the path to earth is very far from straight, and that the choking effect of this circuitous path must be great. It is to be hoped that the manufacturers realize that the resistances are the weak spots in their arresters, and that they will be able to furnish resistances which are free from the trouble of the past.

Transformers Burned Out.—These have been usually small, old, air-cooled type or switchboard series or shunt transformers. Very often transformer fuses are blown or lightning jumps from the transformer lead to the case without injuring the transformer.

Meters Burned Out.—Wattmeters are frequently burned out. The damages are slight, and there is usually no interruption to the service, but the company loses quite a little while the meter is not registering.

Armatures injured.—There has been little trouble with the main generators. In one high-tension plant the two generators, which are well protected by arresters, have burned out repeatedly during mild storms. All burn-outs have been short-circuited coils, and none have been due to discharges to earth. These generators are 200-KW, 6600-volt, three-phase, Y-wound machines, and both the inductance and the length of wire in the armature are consequently very great.

It is very possible that the length of the static wave in the armature is reduced so much by the inductance that it is sometimes comparable in length with that of the wire in the armature. With such short waves, the difference of potential between the lightning arrester taps will be small and the arresters will not protect the generators. The committee's recommendation was to connect lower-voltage arresters across portions of the armature winding, of course leaving no part of the winding unprotected by an arrester. A discharge would jump across one arrester after the other in succession (not simultaneously), and the maximum potential strain would be that necessary to break down each low-voltage arrester.

Suppose, for example, that a short electric wave enters the generator and that its wave length in the armature is just equal to the length of wire between two terminals. The potential difference between the two terminals, due to the discharge, would be zero. If, however, the potential difference across one armature coil were measured, it might be very large. In this case, an arrester placed across the terminals would be of no use, but several connected across the several sections of the armature would be effective.

Very few stations experience similar trouble, for their high-voltage generators are larger, the length of wire in the armature is less, and the inductance is smaller. The electric waves are, therefore, much longer, compared with the length of wire in the armature circuit. It should be noted, however, that trouble in high-voltage transformers may often be due to this cause.

In several cases transformers protected by choke coils and arresters have had the leads punctured on the transformer side of the choke coils. The question is, "what was the good of the choke coils if they did not prevent this?" Possibly the choke coils added just enough inductance and length to the transformer circuit to reduce the potential difference across the arresters for that particular discharge. This trouble was guarded against when choke coils were first used by connecting arresters to both the transformer side and line side of the coils.

The Use of Choke Coils.—These are usually installed in high-tension plants, but in plants under 10,000 volts choke coils are not very common. No argument, for or aginst their use, can be deduced from the replies received, for the main generating stations have had few burn-outs.

Many series transformers on station switchboards have been burned out, both in stations protected by choke coils and in those unprotected.

A considerable part of the discharge must have passed the choke coils to burn out this apparatus. Experiments have shown that choke coils reduce the strain on the ends of the windings of generators or transformers, and they should, therefore, prevent this apparatus from receiving as high a potential strain as that required to break down the arresters.

The Use of Overhead Ground Wires.—Overhead ground wires are rarely used. On distribution lines they are a menace to the linemen, and have been taken down, after trial, by several companies. Barbed wire is especially troublesome. The benefit derived from overhead ground wires on distribution lines is doubtful. On transmission lines they are of undoubted service. The few companies that use them report that they are well satisfied, and some are even enthusiastic. It is still a disputed question as to whether they are worth the cost. There is danger of trouble from breaking of these ground wires unless they are very heavily galvanized iron or heavy copper wires, and either of these would add considerable to the cost of a line.

The Use of Lightning Arresters.—Most companies have learned from "before and after" experience that lightning arresters are absolutely necessary. As to the location of these, many feel that they have not enough on the lines. One very good way of telling where new arresters are required is to keep a special map of the distribution system and mark on this the location of any burn-outs.

Lightning may never strike twice in the same place, but it often makes itself manifest in the same part of a distribution system. A system of different marks can easily be arranged to show what kind of apparatus was injured, how it was protected by arresters, how severe the storm, and so forth. Much more can be learned from such a map than from the records usually kept.

It should be remembered that, except on railway lines, arresters should be located near apparatus to be protected or on junction poles. It is very good to have a general rule as to the proper number of arresters per mile, but the rule should be flexible enough to permit of locating arresters near transformers. If there is a long distance between transformers, the capacity of this line helps very materially in keeping down excessive potential strains, and, therefore, needs no arresters.

On transmission lines arresters should not be scattered along the line, for an arrester is a weak spot on the line and should be placed where it can be inspected from time to time. Apparatus connected to the line needs protection rather than the line itself.

Failures of Arresters.—The chief cause of trouble seems to be due to failure of arresters to discharge, though there was nearly as much trouble due to too violent discharges through arresters. Apparently there is little trouble in the average station from discharges between line wires. Many such discharges, however, may not have been recognized as such. Static discharges are assumed as going to earth unless there is positive proof to the contrary.

Shut-Downs Due to Sudden Changes of Load and Short-Circuits, and Damages Resulting Therefrom.—Short-circuits and sudden changes of load do not seem to have set up high-frequencecy currents that damaged insulation very much. In one plant high-tension cables were sometimes punctured from this cause. In another case a 20-KW. transformer was burned out, and probably this was the cause rather than the result of the short-circuit.

No other short-circuits reported were followed by damages that could have been brought about by high-frequency currents. Experimental tests and several actual examples show how destructive high-frequency currents set up by short-circuits and sudden changes of load may occasionally be, but in the average plant the conditions do not seem to be just right for setting up these dangerous oscillations.

Protection of Poles and Insulators.—One argument for overhead ground wires is that the poles and insulators are protected by them. Only 25 per cent. of the companies replying to this question have had poles struck, and on the poles struck few insulators were broken. One pole was struck for every 2860-KW. capacity of station. One pole was struck for every 19 miles of high-tension transmission line, and one insulator was broken for every 62 miles. Interruptions to service due to broken insulators are very rare, and are confined to special localities. Every company should be able to tell from its past history whether or not special precautions should be taken to guard against broken insulators and poles.

To the question as to whether the damages to apparatus were caused most frequently by severe storms, by mild storms, or by static charges on the wires, practically all who replied had the most trouble from severe storms. Four had the same trouble from static as from severe storms. Arresters which discharge freely, or, in other words, which do not have too much resistance throttling the discharge, should, therefore, be most useful. The long air gap generally required for such an arrester prevents it from handling the occasional trouble from static charges and mild storms. An arrester with a long air gap, part of which is shunted by a high resistance, is equally effective in both severe and mild storms.

The question, "Are lines seriously affected at a long distance from the centre of a storm?" was answered by nearly all in the negative. Some, however, cited special cases where apparatus had been injured several miles from the storm centre. Waves of low frequency may travel long distances on the line until they find a weak spot or are reflected back at the end of the line with increased potential at this point. The ends of long lines should, therefore, be provided with arresters. Those with short gaps and resistances, or with both series and shunted gaps, are most suitable at the ends of lines.

In reply to the question, "Are you satisfied that your apparatus is as fully protected as you would wish?" most of those who had little trouble were satisfied, and most of those who had had trouble felt that there was much room for improvement. The majority thought that this improvement should consist in the installation of more arresters of similar type. Quite a few who "had never had any trouble" were not satisfied with their protective apparatus. They probably felt that they were lucky, and that this luck might change if they gave too much credit to their arresters. Several objected to the large number of angles and bends which the discharge to earth has to make in some of the standard makes of arresters, and many thought that the resistances used could be much improved. Only two or three made severe criticisms.

Experience of the Different Sections of the United States.—The South Atlantic, Central, and Northwestern States appear to have had the most trouble. The Rocky Mountain district reported no trouble except in two large plants in Utah and Colorado. The New England, North Atlantic, Pacific and Southwestern States had about the same amount of trouble as the average of the entire United States.

As more than one-third of all the reports came from New England, New York and Pennsylvania, the conclusions concerning the trouble in most of the United States are based on meagre testimony. Except in New Mexico, Arizona, South Dakota, and Nevada, the reports are very well scattered over the United States.

The portions of the United States in which lightning was most destructive were as follows:—Southeastern Minnesota, Iowa, Missouri, Illinois, Eastern Ohio, North Carolina and Northern Georgia. It may be that the companies reporting from these sections were more unlucky than the others.

Conclusions.—In analyzing the statistics, it should be remembered that complete records of lightning troubles are seldom kept, and many of the figures are very approximate estimates. Any conclusions that may be drawn should, therefore, be qualitative rather than quantitative.

Electric Haulage on the Teltow Canal

A SYSTEM of electric haulage on the Teltow Canal, in Germany, was started early in June. Tractors for hauling the vessels run on tracks at the side of the canal for a distance of twenty-five miles, current being taken from overhead wires. In the power station, close to the canal, two 1000-H. P. steam turbines each drive a three-phase generator and a small direct-current machine. The three-phase machines supply the mains along the whole length of the canal with 50-cycle current at 6000 volts. The direct-current generators supply current for working the tractors in the immediate neighbourhood of the power station. For working the further reaches of the canal a sub-station is provided, in which the high-pressure three-phase current is converted into continuous current for working the tractors. The current thus obtained is not only utilized for haulage, but provides for the lighting of the entire canal, and for the operation of tramways in the district.

Prizes for essays by public school pupils on the domestic uses of electricity were recently awarded by the Mifflin County Gas & Electric Company, of Lewiston, Pa.

Photographic Investigations of Electric Sparks

By DR. ALFRED GRADENWITZ

FIG. 1.—A PHOTOGRAPH OF A SPARK DISCHARGE TRACING THE WORD "ELECTRICITE"

SOME highly interesting investigations on the behaviour of electric discharges have been carried out during the last few years by Dr. Stephane Leduc, of Nantes, France.

A photographic picture of an electrical discharge is obtained by producing the latter in a dark room on the sensitive surface of a photographic plate, which is afterward developed. This process may be used to obtain an infinite variety of ornamental figures which are well suited to decorative purposes, being not unlike those given by kaleidoscopes or derived from nature. Figs. 2 and 3 show several of the figures obtained by Dr. Leduc.

On the sensitive surface of a photographic plate is placed a cut pattern of the form to be reproduced, and a fine powder, such as starch, amylum or metallic oxide, is spread over the plate by the aid of a fine sieve. Upon removing the pattern the powder will be found to have reproduced on the sensitive surface the tracing of the openings.

FIG. 2.—A DECORATIVE SPARK

The plate is placed on metal foil joined to the outer coating of one of the Leyden jars of a Wimshurst machine, and a point connected to the outer coating of the other jar is placed perpendicularly to the sensitive surface in the middle of the tracing. The two poles of the machine are connected respectively with the inner coatings of each jar, the sensitive surface of the plate being protected by a screen against the veil due to the discharge of sparks.

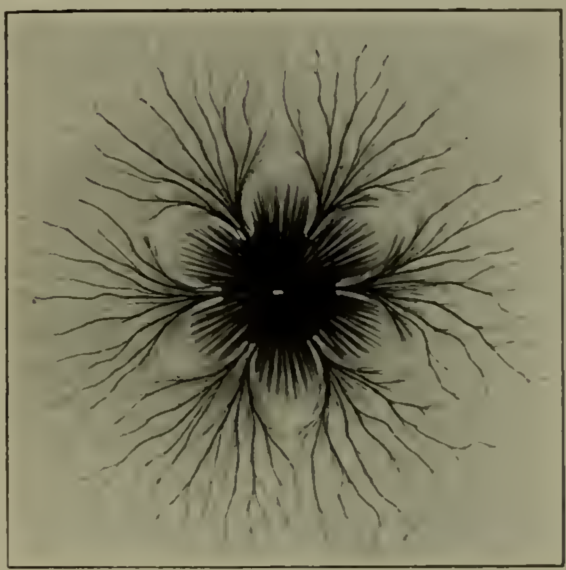
Upon developing the plate an ornamental figure will appear on it, varying in design according to the metallic conductors, the arrangement and nature of the powder, the tension and strength of current, moisture and the temperature of the air. This operation will be found very interesting, as the variety of the factors mentioned results in a great variation in the figures obtained. Letters and words may also be traced in this manner, as shown in Fig. 1, representing the word "Electricité."

Dr. Leduc also uses photography for representing electric fields. Previous endeavours made in this line have given rather poor results, but Leduc's process gives a means of obtaining a highly satisfactory representation of electric fields. Silent discharges are photographed to obtain an image of electric spectra, by arranging the metallic point and plate in exactly the same way in regard to the photographic plate as in producing ornamental designs. In order to photograph disruptive discharges the metal point and plate are likewise connected to the external coatings of the Leyden jars employed.

A metal point resting in the middle of the sensitive surface will give a monopolar field picture, while two points communicating with the same conductor result in a bipolar field picture between the two poles of the same sign, as shown in Fig. 5. Two points communicating with conductors of opposite signs give a bipolar field picture between the two poles of opposite signs, as in Fig. 6. Photographs of the latter are the more difficult to obtain, as the amount of current required is very small. When using a number of points, photographs of multipolar electrical fields will be obtained.

In order to avoid the veil, due to the spark, "anti-halo" plates should be used. Moreover, the plate should be immersed and the discharge effected in compressed red mercury oxide. Fig. 7 shows the image thus obtained between two points at right angles to the surface of the plate.

In this novel picture of electric discharge will be seen an aureola round each point characteristic of the positive or negative sign of the latter, and some coarser lines going from one point to the other. The particles tracing the aureolas show a different behaviour from those pro-



FIGS. 3 AND 4.—DECORATIVE SPARK DESIGNS

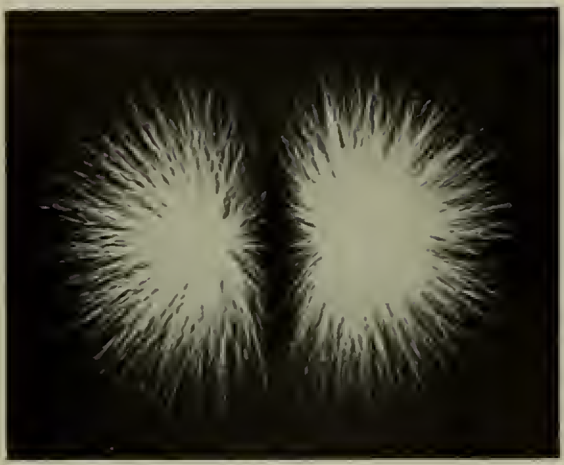


FIG. 5.—A DISCHARGE FROM TWO POLES OF THE SAME SIGN

FIG. 6.—A DISCHARGE FROM TWO POLES OF OPPOSITE SIGN

ducing the lines, their electrical state being different. In fact, the aureolas seem to be formed by the molecules of air attracted by each point. While the coarse lines depend only on the potential difference between the two points, the aureolas depend on that between the point and the surrounding air.

FIG. 7.—A DISCHARGE PHOTOGRAPHED WITHOUT THE HALO OR VEIL, BETWEEN TWO POINTS PERPENDICULAR TO THE PLATE

FIG. 8.—A DISCHARGE BETWEEN TWO POLES, THE NEGATIVE BEING AT THE LEFT AND THE POSITIVE AT THE RIGHT

If the discharge be produced at the same tension, one point being connected to the earth, the aureola surrounding the latter point will be rather reduced and the other aureola will be increased in the same proportion.

Fig. 8 shows a line spark, with the left-hand point negative and the right-hand point positive. Its appearance is accounted for by supposing the lines to be traced by such particles as have received, at the contact of either point, a charge of the same sign, thus being repelled and attracted by the other point. These particles carrying electrical charges will attract neutral molecules which, on being directed towards the point, trace the aureola. In the middle of the spark there is a neutral zone without an aureola, the particles of the two halves being thrown against one another with opposite charges, so as to neutralize each other.

When using a point as one of the electrodes and a plate as the other, the discharge will take place only in one direction from the point toward the plate, the aureola showing throughout its length the character of the discharge, whether positive or negative. A positive discharge will appear as in Fig. 9, and a negative discharge as in Fig. 10.

FIG. 9.—A DISCHARGE FROM A POSITIVE POLE WITH THE PLATE AS THE NEGATIVE

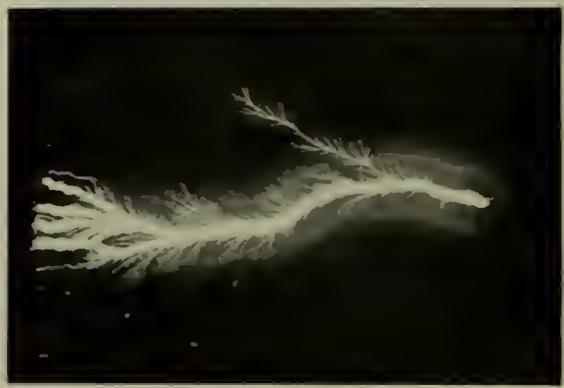


FIG. 10.—A DISCHARGE FROM A NEGATIVE POLE WITH THE PLATE AS THE POSITIVE

Telephones in Mines

The principal points to overcome in installing mine telephones, according to "The Engineering and Mining Journal," are dampness, induction, vibration, and difficulties of installation.

In overcoming the first it is necessary, where wires run down shafts, to use lead-encased rubber-covered wire. This should be run or enclosed in an iron pipe of sufficient size; it will be found from experience that the small lumps that continually fall from the cage or hoistway will in a short time wear the lead cover to pieces; hence the iron pipe. Often, after reaching the foot of the shafts, it is desired to extend the line some distance into the mines; by separating the wires a sufficient distance (2 feet is good practice), using No. 12 rubber-covered wire, the induction effect is minimized. For work in mines where electric traction or power feeders are installed, the distance should be increased.

The chief trouble with the major part of telephone installations in the mines is the utter disregard of conditions that are required to be met. The constant dampness, and the movement of the roof, as well as other mechanical injury that is apt to occur, are too often lost sight of. Wherever there is any chance of the line coming in contact with the roof, the spot should be plugged for an insulator; a $\frac{1}{2}$-inch square wooden plug is usually sufficient distance between the pairs of plugs to prevent induction.

The instrument should be secured to a solid plank in a place that is selected for its freedom from moisture as well as for its convenience. By using No. 12 rubber-covered wire properly stretched and bound to insulators, there will be little or no trouble.

The average expense of maintaining a system of six instruments is about $40 per year. This expense is necessitated by the purchase of new batteries, repairing brakes, etc. In some slopes it is found more practicable to run wires on the roof, especially if it be level; in other cases it will be found more practicable to run them on the side. The cars in running down the slope sometimes jump the track, the rope becomes tangled, and the line wires are apt to be torn and otherwise damaged.

It is reported that in order to increase the traffic facilities on the Berlin Elevated Railroad the plan of using two-story cars is being considered. The German Society of Mechanical Engineers has offered a prize of 6000 marks (about $1400) for a feasible design.

Line Construction for Overhead Light and Power Service

By PAUL SPENCER

A Paper Read at the Atlantic City Convention of the National Electric Light Association

AN electric light and power system can broadly be divided into three parts, the generation, the distribution, and the utilization of the current. The progress made in two of these departments, namely, the generating and the utilization of the current, has been constant and rapid. The greatest possible care and thought have been given to designing and building the power station and to its equipment with machinery that will insure uninterrupted service.

The improvement in the reliability of arc and incandescent lamps, of motors, and of all other appliances for transforming the current into useful work, has also been a matter for careful engineering study. But the central link in the chain, the distribution of the current from the power station to the consumer, has received much less attention.

Granted conditions where underground construction is economically feasible, the distribution problem stands a chance of intelligent consideration and of being satisfactorily solved along engineering lines, with proper consideration given to reliability of service, freedom from accidents, safety to the public and employees, and the future growth and development of the situation.

But the possibility of underground distribution is limited to more or less thickly settled territories. Considering electric light companies as a whole, the largest extent of the territory covered must be reached by overhead lines. And when it comes to overhead distribution, the engineer seems to have thought the matter too trifling for his efforts, and to have left the problem to solve itself or to be worked out by the rule-of-thumb methods of the line gang.

The result is shown in the generally poor construction of overhead lines throughout the country and by the general belief that overhead service is much more unreliable than underground service, and is responsible, in a great measure, for the agitation in favour of placing wires underground, even in localities where the cost of the necessary underground construction is out of all proportion to the revenue to be obtained in the territory. The writer does not believe that the objections to overhead lines can be altogether eliminated. A pole line can never be said to be, in itself, an artistic creation, a thing of beauty, or an ornament to the landscape; but with more care given to the construction, such lines can be made safe and reliable and their unsightliness reduced to a minimum, so as to be unobjectionable as compared with the benefits of the electric service, which only their use will permit.

The problem of constructing a satisfactory overhead line is not an easy one. There are many conditions that are not altogether in the control of the line superintendent. Suitable pole locations are frequently difficult to obtain. The highway along which the line must run is generally, to some extent at least, obstructed by trees which can only be trimmed sparingly, and may also be occupied by the lines of other companies, whose construction must be taken into consideration to avoid an unsightly and dangerous tangle of poles and wires.

The back alleys of some of the smaller cities, where alley construction is in vogue, illustrate the hopeless mess which results when two or more electric light and telephone companies build their lines without reference to the lines of the other fellow. To avoid such conditions and to construct well-built lines should be the endeavour of every electric light manager whose service, in whole or in large part, is supplied by overhead construction.

The points to be considered in line construction in the order of their importance are the following:—

First and foremost, to which all others must be entirely secondary,—the safety of the public and the company's employees.

Second,—the reliability of the company's service.

Third,—sightliness of the construction.

The question of cost has been omitted altogether, as the cost of a well-built line over that of a poorly-built line should be of no moment as compared with the much greater safety and reliability of the former construction.

These first two requirements, safety and reliability, can be considered together, the first embracing the second, for safe construction implies reliability of service. To meet these requirements we should use, first of all, structurally sound material, of ample strength to withstand, under all conditions of service, the strains to which the line may be subjected.

The poles should not have less than 7-inch tops, should be set not less than 5 feet in the ground and be held firmly, by substantial guying against side or end pulls. The cross-arms should be of sound, honest wood, and not the sap-wood variety, which are covered with so-called red paint to hide their defects, and which are made up of the leavings of the mills after the good wood has been cut into building timber and flooring. They should be firmly bolted to the pole and should be braced.

The line wires should not be less than No. 6 B. & S. gauge in size, and they should be strung with ample clearance over highways and footways, and should be inaccessible to the general public from bridges or buildings.

The guy wires should be of stranded cable and not solid wire. They should be insulated, and, so far as possible, installed so they cannot be easily reached from the ground.

Ground wires should not be installed unless they can be connected to a permanent and effectual ground. A ground wire connected to a poor ground not only fails when it becomes charged to give the protection for which it is supposed to be installed, but becomes a positive source of danger to the passer-by.

For the safety of employees, pole wiring should be carried out in a systematic manner, so as to leave space on the pole for climbing and working. To protect the trimmer, series arc lamps should have absolute cut-outs.

Due consideration should be given to the wires of other companies in the territory. We must remember that the telephone and fire-alarm wires have much less mechanical strength than the line wires used by electric light companies, and that in case of sleet-storms they are the ones that are likely to break and come down, making possible contact with the electric light wires.

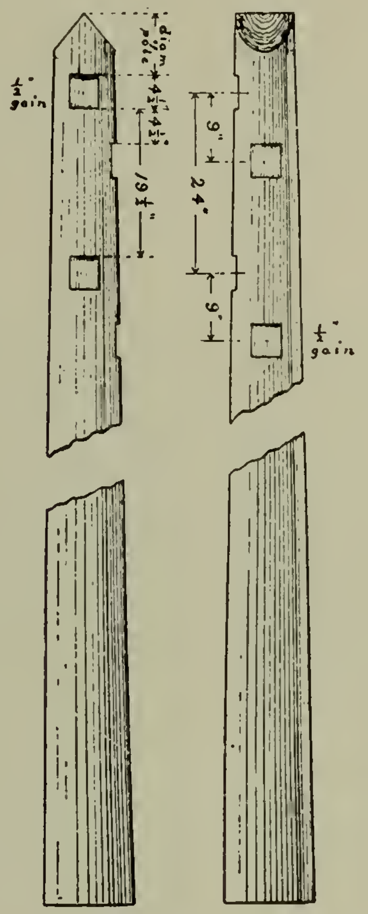


FIG. 1.—POLE FRAMING

The writer does not believe in installing guard wires as a protection against such possible crosses with other wires. The stable and proper installation of such guard wires in a general distribution system is impracticable, and as they would generally have to be installed, they would increase rather than lessen the chances of trouble. When electric light, fire-alarm and telephone wires must be run in proximity, the best results to all concerned and to the public will be obtained by having the electric light wires on top and above all other wires, and when they must be run on the same side of a highway, joint occupancy of a single pole line is preferable to separate and conflicting pole lines.

Sightliness of construction will be best obtained by having the work done in a systematic manner and by using poles of a uniform height and size, set and maintained perpendicularly. The cross-arms should be of uniform length.

Wires should be pulled up with similar sag, and should not be left with any greater amount of sag than is necessary to relieve the strain due to contraction at low temperature. Systematic pole wiring, with taps for transformer connections and for branch circuits led across the pole horizontally and dropped perpendicularly, will do a great deal to help the looks of things. Nothing is more unsightly than a pole with wires crossing it and leaving it in all directions and at all angles.

After the line is completed there remains the necessity of constant inspection and maintenance in order to keep it in good condition.

The above points have been enumerated in order to call attention to some of the most important items that enter into the problem of line construction. The subject is one of endless detail, and it may be of interest to quote at some length from the line specification recently prepared for the electric companies of the United Gas Improvement Company and of the Public Service Corporation of New Jersey. Omitting many paragraphs which deal with minor details, the principal sections are as follows:—

POLES

Specification.—All poles used must be purchased under, and conform to, the company's standard specification. Round chestnut poles should be used where possible, but wooden piles other than chestnut may be used in localities where it is difficult to obtain chestnut poles. If municipal regulations require a finished pole, yellow pine poles, in accordance with the company's specification therefor, may be installed.

Chestnut poles should be of sound, live, straight chestnut, squared at both ends, well proportioned from butt to top, peeled, and with knots trimmed close.

The poles should be of the following dimensions:—

Length of Pole	Circumference 6 feet from Butt Not Less Than	Circumference at Top Not Less Than
30 feet	37 inches	22 inches
35 "	41 "	22 "
40 "	44 "	22 "
45 "	47 "	22 "
50 "	50 "	22 "
55 "	53 "	22 "
60 "	57 "	22 "
65 "	60 "	22 "
70 "	63 "	22 "
75 "	66 "	22 "
80 "	70 "	22 "

Sawed octagonal poles should be made of long-leaf yellow pine, sound, straight grain, and free from sapwood and unsound or large knots.

The dimensions are as follows:—

Length	Diameter at Top	Diameter at Butt
25 feet	7 inches	10 inches
30 "	7 "	10½ "
35 "	7 "	11 "
40 "	7 "	12 "
45 "	7 "	14 "

NOTE.—Diameters given are the diameters of the inscribed circle.

Poles should be finished smooth. Butts are sawed square and the tops pointed at an angle of 60 degrees. The cross-section of the finished poles, at any point, is a true octagon.

Poles are shipped unpainted, but are given one coat of boiled linseed oil before shipment.

Poles are inspected at point of delivery, and all poles not in accordance with these specifications should be rejected.

Height.—Unless taller poles are required by municipal ordinance, or by exceptional conditions, the standard height in cities or thickly settled localities should be 35 feet for poles to carry either one or two cross-arms, 40 feet for poles to carry three or four cross-arms, and 45 feet for poles to carry over four cross-arms. For lines in suburban districts 30-foot poles may be used to advantage, and their use is recommended. In general, stability of construction is sacrificed by using poles higher than necessary. The height of a pole is always considered as the total length over all.

Trimming.—Before being set, poles should be well trimmed and shaved, every effort being made to have their appearance when set as unobjectionable as possible. The top of each pole should be roofed at an angle of 45 degrees, as shown in Fig. 1.

Cross-Arm Gains.—Gains for the cross-arms up to the expected carrying capacity of the line should be cut in a pole before the latter is set. Gains should be cut square with axis of pole, and with all other gains: they should be 4½ inches wide to securely fit the cross-arms, and should be ½ inch deep and spaced 24 inches

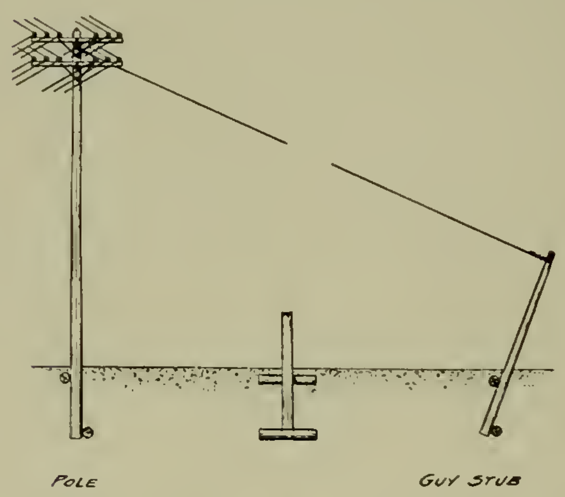


FIG. 2.—CRIB BRACING

apart on centres, as shown in Fig. 1. The gains for ten-pin cross-arms are 5 inches wide. The distance from the peak of the pole to the top of the upper gain is 9 inches.

Painting.—Poles that are to be painted are given a priming coat of standard green pole paint before being taken from the yard, special attention being taken to paint thoroughly the roof, gains and parts of the pole to be set in the ground. After the pole is set, and construction line work thereon has been completed, the pole is given a second or finishing coat of standard green pole paint. Cross-arm braces, pins, switch-

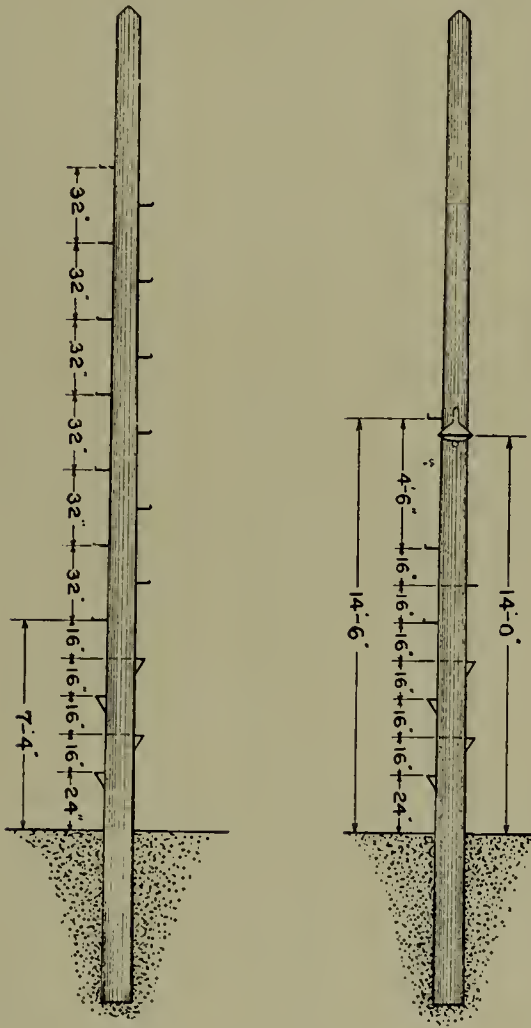


FIG. 3.—LOCATION OF POLE STEPS

boxes, wooden pole steps and other pole fixtures are painted at the same time.

Pole Numbering.—In order that complete records of the locations and number of poles in use may be kept, it is necessary that every pole belonging to the company, and every pole that is the joint property of the company and of some foreign company, be numbered and the initial letters of the company marked thereon.

Spacing.—For heavy trunk lines to carry three or more cross-arms, the spans should not exceed 110 feet. For main lines to carry two cross-arms, the spans should not exceed 125 feet. For branch lines that will never carry more than one cross-arm, the spans should not exceed 140 feet.

Street Rights of Way.—Pole lines on streets are preferable to those over private property. Where possible, poles should be located at the corners of intersecting streets. Lines should be laid out to follow one side of the street, so that the number of street crossings shall be a minimum. In laying out a new line, care should be taken to obtain an unobstructed right of way. Select the side of the street most free from trees and avoid erecting pole lines that will conflict with existing pole lines of other companies. Objection should always be made to the erection by other companies of pole lines paralleling and on the same side of the street as existing pole lines of this company.

Line Level.—The lengths of poles are so proportioned to the contour of the country, or to adjacent poles of exceptional height set to clear obstacles, that abrupt changes in the level of the wires will not occur.

Pole Setting.—Poles should be set in the ground to depths specified in Table I. At line terminals, corners, curves, and other points of excessive strain, poles are set in the ground an additional 6 inches. They should be set to stand perpendicularly when the line is completed. Exception can be taken to this rule in that a very slight lean against the strain can be given to poles at line terminals, corners, curves, and other points of excessive strain.

TABLE I.—POLE DIMENSIONS AND SETTINGS

	Minimum Cir.		Depth in Ground	
Length Over All in Feet	6 Ft. from Butt	Top	Straight Lines	Curves, Corners and Points of Extra Strain
30	37″	22″	5.′	6.′
35	41″	22″	5.5′	6.′
40	44″	22″	6.′	6.5′
45	47″	22″	6.5′	7.′
50	50″	22″	6.5′	7.′
55	53″	22″	7.′	7.5′
60	57″	22″	7.′	7.5′
65	60″	22″	7.5′	8.′
70	63″	22″	7.5′	8.′
75	66″	22″	8.′	8.5′
80	70″	22″	8.′	8.5′

Crib-Bracing.—Poles which cannot be strongly guyed and which must be set in soft ground, may be given additional stability by crib-bracing, as shown in Fig. 2. This consists in placing at the points of maximum strain two logs, about 5 feet long and not less than 8 inches in diameter. These furnish considerable extra bearing surface, tending to hold the pole in position. The top brace alone, or both braces, can be used according to the amount of additional stability required.

Poles to Be Stepped.—All poles carrying branch cut-outs, incandescent lamps or other attachments that may require frequent attention, as also all testing poles, are stepped to facilitate climbing them. For the same reason, it will be found convenient to step poles carrying transformers. The location of steps on a pole is shown in Fig. 3. They should always be placed on a line with the street on which the pole is located.

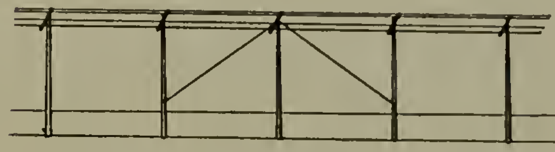


FIG. 4.—STRAIGHT LINE GUYING

POLE GUYING

When to Use Guys.—Guys should be used whenever they can be located so as to counteract the strain of the wires attached to a pole, and so prevent the pole from being pulled from its proper position in a line. The following general instructions cover some of the special cases where guying may be required. On straight lines carrying more than one cross-arm, poles should be head-guyed at convenient intervals, i. e., guys should extend from the top of a pole to the butts of the adjacent poles in the line on either side. If possible, this same pole should be side-guyed, i. e., guys should extend from the top of the pole on either side at right angles to the line to guy stubs or other supports.

On street lines, side-guying can be employed only in comparatively few instances. Straight line guying is for the purpose of giving additional stability to a line in case of severe storms, and is illustrated in Fig. 4. Line terminal poles are head-guyed, and on heavy lines the two poles next to the terminal poles are head-guyed to assist the latter in taking the terminal strain, as in Fig. 6.

Poles at the terminals of long spans are guyed to counteract the extra strain on the pole due to the long

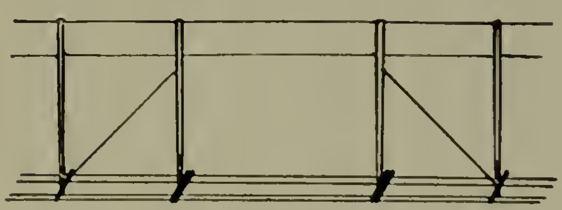


FIG. 5.—HEAD GUYING

span, as shown in Fig. 5. In turning a corner with one pole, guys are preferably placed as shown in Fig. 7. In turning a corner with two poles, guys are preferably located as shown in Fig. 8.

On curved lines carrying not more than one cross-arm, the guys are located in a line with the radius of the curve on every pole with an offset of more than 10 feet. On lines carrying more than one cross-arm, a guy is located on every pole having an offset of more than 5 feet. Poles on steep hills are head-guyed.

Guy Wire.—The material used for

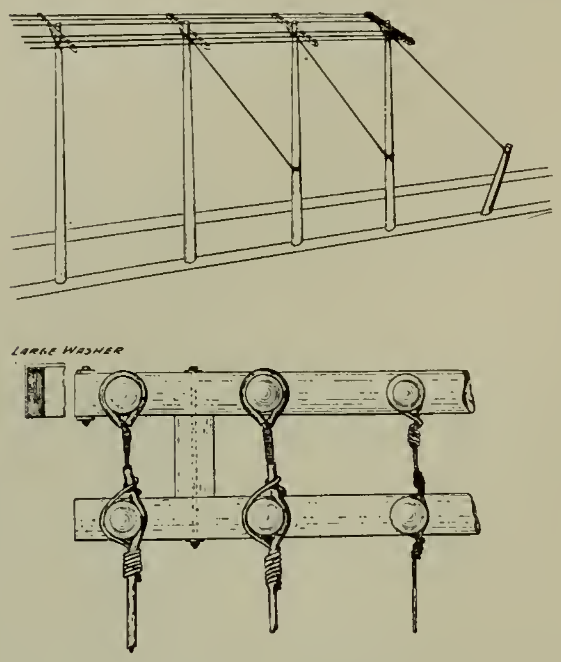


FIG. 6.—METHOD OF DEAD-ENDING A LINE

guying should be standard cable composed of galvanized iron or steel wire. The standard guy cable consists of seven strands of No. 12 B. W. G. galvanized iron wire. A smaller cable may be used for guying cross-arms and light poles, but no cable of less diameter than one-quarter inch should be used, nor should solid iron wire be used for guying poles or cross-arms. In connection with the stranded cable, galvanized iron guy clamps and thimbles should be used. Wrapped joints should not be made in guy wire when clamps can be employed.

Guy Attachment.—All guy wires are preferably attached to poles, guy stubs, trees or other ungrounded supports, and when so attached should not reach within 8 feet of the ground. Unless such attachment be absolutely unavoidable, guy wires should not be attached to rocks, stone foundations, iron structures or other grounded supports, and such attachments to structures are made only with the consent of the owner, and in such a manner that there is no danger of any damage to, or interference with, the free use of the structure.

On poles carrying extra-high-potential wires, guys should not be attached to the cross-arms carrying these wires, nor to the pole at or above these cross-arms. When two or more guy wires run to a pole, guy stub or other support in close proximity to each other, the attachment of one guy should never overlap that of another, but be entirely independent. In new construction work, and in rebuilding old lines, guy wires are placed and pulled to the required tension before the lines are strung.

Stub-Guying.—When a line cannot be properly guyed by means of other poles in the vicinity, guy stubs are set, as shown in Fig. 2. Guy stubs should be of sound chestnut, at least 8 inches in diameter, and of sufficient length to raise the attached guys to the proper height from the ground or from obstacles as herein specified. They are set in the ground to a depth of at least 6 feet, leaning away from the pole to be guyed, and set in the ground according to specifications applying to poles. Special stability of guy stub setting may be obtained by the use of crib-bracing,

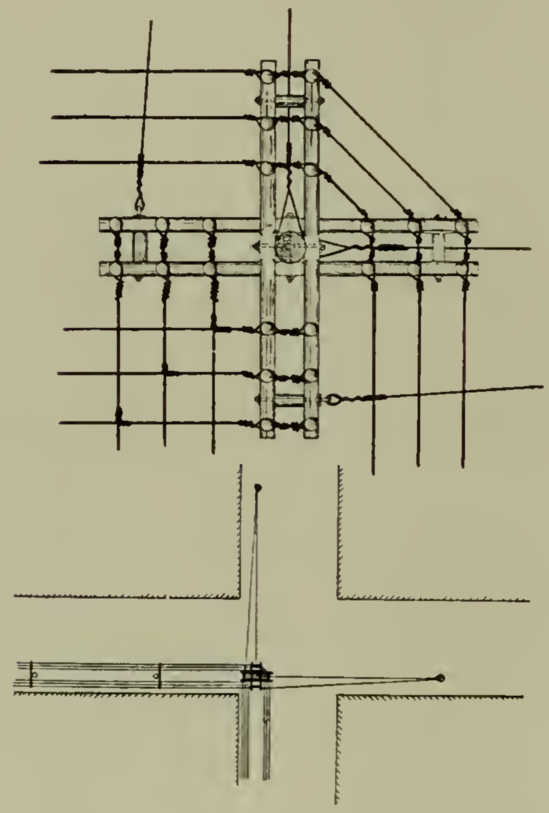


FIG. 7.—ONE-POLE METHOD OF TURNING A CORNER

as indicated in Fig. 2, or by concrete setting.

Anchor Guys.—An anchor guy may be employed to guy poles, but must not be installed when it might interfere with surface traffic. It is constructed as shown in Fig. 10. A ¾-inch iron eye-bolt about 7 feet long is attached at the middle of, and at right angles to, a wooden anchor, consisting of a cross-log of sound chestnut, not less than 8 inches in diameter, and about 5 feet long. This anchor is set in the ground so that the eye of the guy rod stands about 1 foot above the ground, the guy rod being in line with the guy wire attached to it. The guy rod is attached to the anchor by means of a washer and nut.

Tree-Guying.—When neither poles nor guy stubs can be obtained to which to fasten guy wires, conveniently located trees may sometimes be used. Guy wires should not be attached to trees without permission of the owner or other proper authorities. Tree guys are preferably attached to tree trunks. When this is impossible, attachment may be made to a live sound limb, close to the tree trunk, provided the limb is not less than 8 inches in diameter.

Tree trunks and limbs should always be protected from injury by the use of tree-blocks between the tree and the wire attached to it. Tree-blocks should be of chestnut, and should be placed around a tree trunk or limb sufficiently close together to prevent the wire from touching it. To avoid injury to the tree, guy wires should not be wrapped continuously around it, but should simply pass around the tree, supported on blocks, as shown in Fig. 9.

Clearance.—Guys should be attached to poles so as to interfere as little as possible with workmen climbing or working thereon. Every guy which passes either over or under any electric wires other than those attached to the guyed pole should be so placed and maintained as to provide a clearance of not less than 24 inches between the guy and such electric wires, under all conditions of temperature and sag. As changes in temperature will affect the sag of

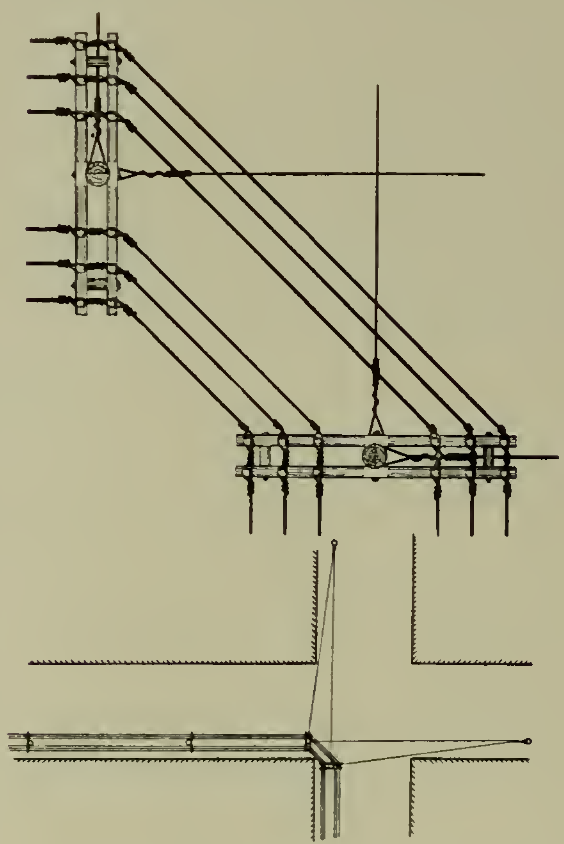


FIG. 8.—TWO-POLE METHOD OF TURNING A CORNER

the wires more than that of the guy, the latter being under strain, allowance must be made for this at the time the guy is installed.

Guy Insulation.—All guy wires attached to poles carrying electric light or power wires should be insulated by the insertion of at least one strain insulator. In the case of head guys and side guys, the insulator is located at the upper end of the guy, and at least six feet from the pole, measured horizontally. Where any portion of the guy passes under electric light or power wires, other than those attached to the guyed pole, a second strain insulator is used, placed 6 feet from the lower end of the guy.

Guy wires which are attached to a non-insulating support, such as a rock, iron pole, bridge, or any other structure, and anchor guys, should have inserted in them two strain insulators, one being so placed as to protect a man working on the pole from coming in contact with that portion of the guy beyond the insulator, and the other placed so as to be out of reach from the ground or structure.

CROSS-ARMS

Specification.—All cross-arms used must be purchased under and conform to the company's standard specifications. The dimensions adopted by any company will depend somewhat on the character of the service and the surrounding conditions, and should be uniformly adhered to. The following specification covers the purchase of cross-arms, and the dimensions for two different classes are shown in Figs. 11 and 12.

Cross-arms shall be made from sound, straight grain, long-leaf yellow pine, free from sap wood, shakes and unsound knots.

The dimensions shall be as shown in Figs. 11 and 12. All cross-arms shall be sawed true and square, and the centres of holes shall be on the centre lines of the arm.

Cross-arms shall not be painted, but as soon as cut and finished shall be stored so as to be protected from the weather until shipped. No kiln drying or other artificial methods of seasoning shall be used.

Cross-arms shall be subject to inspection at point of delivery, and all arms not conforming to the requirements of this specification shall be rejected.

Painting.—Cross-arms should be kept under cover until seasoned, and then painted with two coats of standard green white-lead paint before being placed on poles.

Fitting Cross-Arm to Pole.—When possible, cross-arms should be fastened to a pole before the latter is set. Before being placed on a pole, each cross-arm is fitted with two braces, attached to the cross-arm by carriage bolts. When the cross-arm is placed in position, with the braces facing away from the pole, an eleven-sixteenth-inch hole is bored

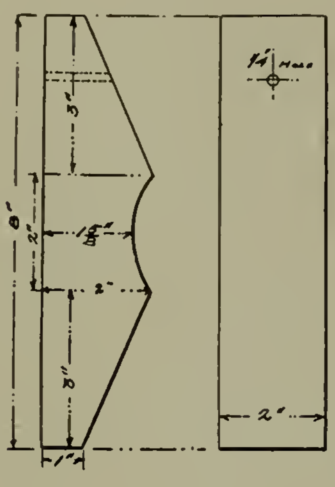


FIG. 9.—TREE BLOCKS FOR PREVENTING INJURY TO THE TREE FROM GUY WIRES

through the centre of the gain, and a five-eighths-inch cross-arm bolt driven through the cross-arm and pole.

This cross-arm bolt is of just sufficient length to pass completely through the pole and cross-arm and receive its complement of washers and nuts. One square washer is placed under the head and one under the nut at the end of the bolt. The back of the pole should never be cut out to allow the use of a shorter bolt, and projecting bolt ends should not be left on.

Cross-arms should invariably be placed either at right angles or parallel to the line of the street on which pole is set, and they should always be faced on the opposite side of the pole from that in which the maximum strain comes. On straight lines where the spans between poles are equal, the cross-arms are faced alternately on succeeding poles, in first one direction and then the other, as shown in Fig. 4.

Double Arms.—At line terminals, corners, curves and other places where there is excessive strain on the cross-arms, pins and insulators, the pole is double-armed, as shown in Figs. 6 or 13. Where wires cross from one side of the street to the other, the two crossing poles are double-armed, the arms being at right angles to the line of the street. The cross-arms on poles adjacent to crossing poles should face toward the crossing.

At line terminals, the last pole is double-armed and the cross-arms of the last two poles before the terminal pole faced toward the latter. In turning corners with two poles, the corner pole is double-armed, as shown in Fig. 8. In turning corners on one pole, double-arming may be used, as shown in Fig. 7, if the reverse arms do not cut down the space between the nearest wires and the cross-arms so as to make it difficult for the men to climb through. Where on corner poles the use of double arms would reduce the clear space to less than twenty inches, the double-arming should be omitted and the line held by double-arming on the adjacent poles to the corner pole, as in Fig. 14. If the corner cannot be securely turned without the use of double arms on the corner pole, longer cross-arms should be used and the wires shifted to provide a clear space of 24 inches between the inside line wires and the nearest face of the pole.

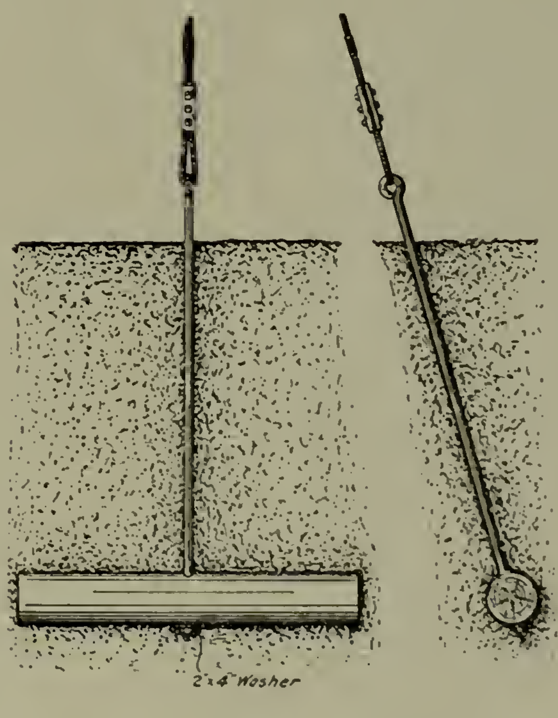


FIG. 10.—AN ANCHOR GUY

Pins.—Before being taken from the yard, each cross-arm should be fitted complete with 1½-inch standard pins. A detail drawing of a standard locust pin, giving dimensions, is shown in Fig. 15. Pins should fit tightly into the holes in a cross-arm, should stand perpendicularly to the cross-arm when fitted, and be nailed to it with one six-penny nail driven straight from the middle of the side of the cross-arm.

Insulators.—The standard form of insulator for direct-current circuits of all voltages and for alternating-

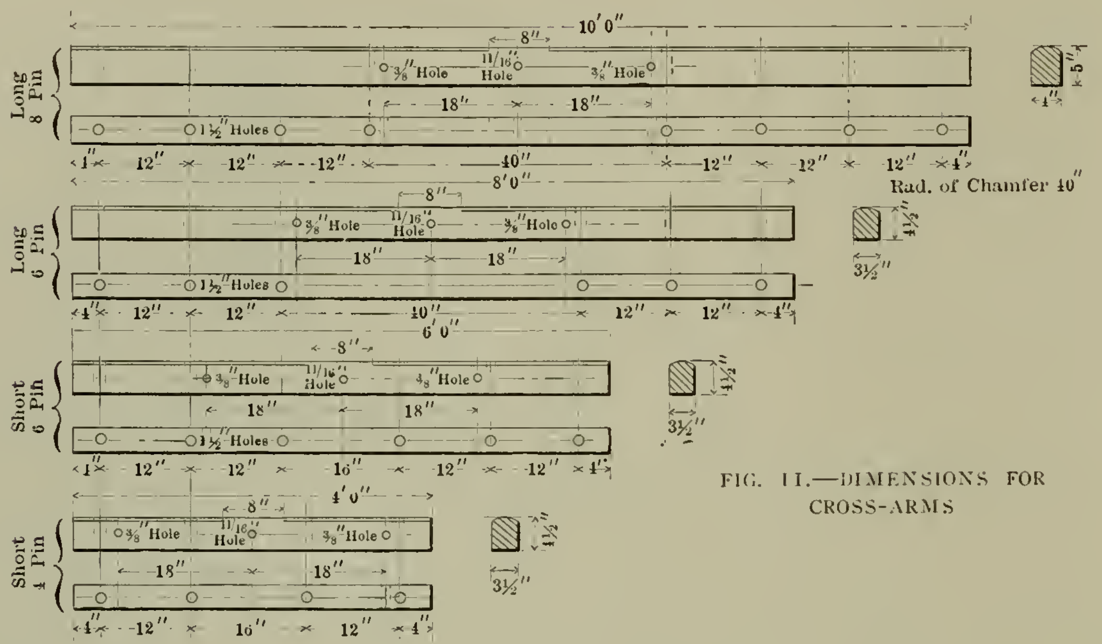


FIG. 11.—DIMENSIONS FOR CROSS-ARMS

current circuits up to 3500 volts should be the deep-groove, double-petticoat, flint-glass insulator. For alternating-current circuits exceeding 3500 volts and not exceeding 5000 volts, the triple-petticoat glass insulator should be the standard. Triple-petticoat glass insulators may also be used for alternating-current circuits under 3500 volts, to reduce noise on telephone wires due to leakage from electric wires on poles jointly used by electric light and telephone wires. For constant-potential lines having a voltage exceeding 5000, special insulators of approved pattern should be used.

Insulators should be placed upon

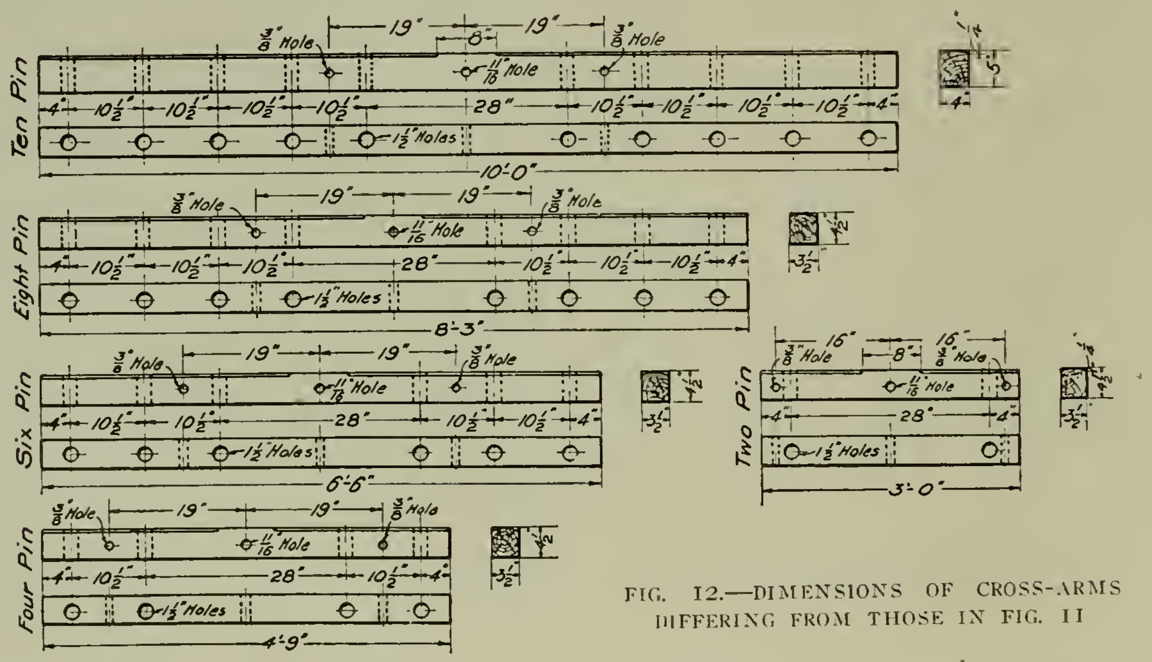


FIG. 12.—DIMENSIONS OF CROSS-ARMS DIFFERING FROM THOSE IN FIG. 11

the cross-arm pins only when the wire is to be immediately attached thereto, and should be screwed up tightly in every case. If a wire be permanently removed from an insulator, and no other is to take its place, the insulator should also be removed.

WIRE AND WIRE STRINGING

Wire Specification.—Up to and including No. 0 B. & S. gauge, solid wire should be used for lines. Stranded cable should be used for all wire larger than No. 0 B. & S. gauge. No wire of smaller size than No. 6 B. & S. gauge should be used for line wire. For service connections, not more than 75 feet in length, and not crossing a street, No. 8 twin or single conductor may be used. The standard insulation for line wires should be an approved triple-braided weatherproof covering.

Wires Attached to Structures.—High-tension lines should not be supported upon trees, nor should they be attached to buildings. When they must be attached to bridges every effort must be made to so place the wires that they will be entirely inaccessible to the general public. When a high-potential series circuit must be attached to a building in order to supply commercial series arc lighting in the building, the wires must be installed in such a way as to be beyond the possibility of accidental contact by people in or about the place, and also so as to avoid possibility of contact with awnings, shutters, signs and similar fixtures on the building. Line wires should not be attached to wooden bracket-pins.

Clearance.—The clear space between the crown of the road and wires crossing it should always conform to municipal ordinances or rules, but in no case should such clear space be less than 21 feet. Similarly, the clear space between sidewalks and wires crossing them should never be less than 15 feet. High-tension wires should clear all roofs in such a manner that the wires cannot be reached from the roof. They should clear other wires, or guy wires above or below, by not less than 24 inches except where attached rigidly at poles, and should be run so that they cannot be readily reached from any building or structure.

Tree Trimming.—It is essential for the safe and uninterrupted operation of high-tension lines that they be free from the possibility of grounding on trees. It is, therefore, important that tree branches interfering, or likely to interfere, with the lines should be cut away. Such trimming must be done with care and judgment and under the immediate supervision of the superintendent, line foreman or other responsible person.

Before any trimming is done, the consent of the owner of the trees should be obtained. Opposition to tree trimming may sometimes be overcome by offering to employ a professional gardener for this purpose. If consent to trim trees cannot be obtained, tree wire should be used. Trees can generally be best trimmed in the fall and winter months, when the leaves are off, and the result of the work will be less noticeable. When branches have been cut off they should not be left to litter the streets, nor thrown into the nearest vacant lot, but should be removed in the company's wagons. The stubs of branches should always be painted for their protection and to make them less noticeable.

Running Through Trees.—When lines must be carried through trees that cannot be cleared or trimmed so as to give a clear passage for the wires, tree wire of approved insulation should be used. This insulation consists of a three-thirty-second-inch rubber cover, taped, and with two braids over all.

Abrasion Moulding.—Where tree wire is used, if there is danger of limbs or large branches chafing the insulation, it should be protected by means of wooden abrasion moulding. A satisfactory form of wood moulding is shown in detail in Fig. 16.

Line Sag.—By means of jack-strap, blocks and tackle, or other device, wires should be pulled up

FIG. 13.—A DOUBLE CROSS-ARM

until the sag or dip in the line between supports is as specified in Table II. As will be seen from the table, the dip below horizontal is the same for all sizes of line wire, but varies with the length of the span and with the temperature of the air at the time the work is done. Therefore, wires stretched between two poles should all hang parallel to each other.

TABLE II.—DIP IN ANNEALED COPPER LINE WIRE

DEFLECTION IN INCHES

Span in Feet	Temperature in Degrees Fahrenheit						
	30°	40°	50°	60°	70°	80°	90°
50	8	9	9	10	11	11	12
60	10	11	11	12	13	14	14
70	11	12	13	14	15	16	17
80	13	14	15	16	17	18	19
90	14	16	17	18	19	20	21
100	16	17	19	20	21	23	24
110	18	19	21	22	24	25	26
120	19	21	23	24	26	27	28
140	22	24	26	28	30	32	33
160	26	28	30	32	34	36	38
180	29	32	34	36	39	41	43

Soft-drawn copper wire, ultimate tensile strength 34,000 pounds per square inch. Triple braided weather-proof insulation. Factor of safety 4. Minimum temperature 20° F.

Splicing Wires.—Every joint and tap should be carefully soldered and taped.

Branch Lines.—When only one or two wires branch from a pole, the tap should be made by the use of spreader brackets, as shown in Fig. 17. If the branch line carries more than two wires, a reverse-arm should be used. All bends in wires should, if possible, be at right angles. When strung in position, all wires should be entirely free from crooks and kinks, and should not hang loosely between supports. Loosely hung or kinked wires are not only unsightly, but are indicative of poor line work. Carrying wires across the face of a pole at right angles, and necessarily without proper supports, not only increases the liability of trouble, and makes trouble-hunting and repair work difficult in the confusion of wires, but unnecessarily makes the wires an eye-sore to the public.

Corners.—At right-angle corners in heavy lines, when possible, turn by means of two poles, as shown in Fig. 8. A corner with only one pole may be turned, as shown in Fig. 7. The double-arms are omitted, if necessary, to provide space for climbing, and the turn made as shown in Figs. 14 and 18. When guys will hold the pole securely, the line wires can be pulled tightly around the corner, but when guys are weak, the strain of the wires should be correspondingly lightened.

Dead Wires.—All wires temporarily out of service should be left on the poles, but should be cut dead, as their connection to a current-carrying circuit only needlessly increases the chance of trouble on the lines. Wires permanently out of service should be at once entirely removed from the poles.

Systems of Distribution.—Commercial circuits must be designed to furnish practically uniform voltage throughout a system of distribution, otherwise satisfactory lighting or power service cannot be supplied to consumers. To secure this end, so far as possible, all constant-potential circuits are laid out on the feeder and main system, feeders being run from the station or sub-station to some point of distribution centrally located in the district to be supplied.

From this centre of distribution, the mains radiate in such a manner and are of such a size that the drop in potential will be as uniform as possible, and as low as is warranted by the costs of construction. The drop of potential in the feeder, between station or sub-station and the centre of distribution, should not exceed 10 per cent. of the delivered voltage. Potential regulators may be used to advantage on feeder circuits, and when the drop exceeds 10 per cent. they should be used.

In general, consumers should not be connected to feeders when they can be supplied from distributing mains or branches. Branch lines or mains on the 500-volt power circuits should be tied together so far as possible, thereby providing an interconnected network of wires throughout a district. Branch lines or mains, however, supplied by separate feeders, should not be so interconnected.

Temporary Work to be Avoided.—All construction and extension work on circuits should be of a permanent character, both as to the routes followed and the quality of line work. Rush work, short-cuts, skimped materials, and other such attempts to hasten the completion or reduce the initial cost of circuit extension, should be avoided.

LOCATION OF WIRES

Series Circuits.—Series circuits should start from the station, sub-station, or other point of distribution on a given pin and cross-arm, and should follow this same relative pin and cross-arm throughout its course. Circuits should not jump from one location on a cross-arm to another location on the same cross-arm, or to a different cross-arm, but should always be placed on their proper pin.

Such a system of confining each circuit to a given pin throughout its course makes trouble-hunting and repair work much simpler than they otherwise would be, and is the only possible way in which circuits can

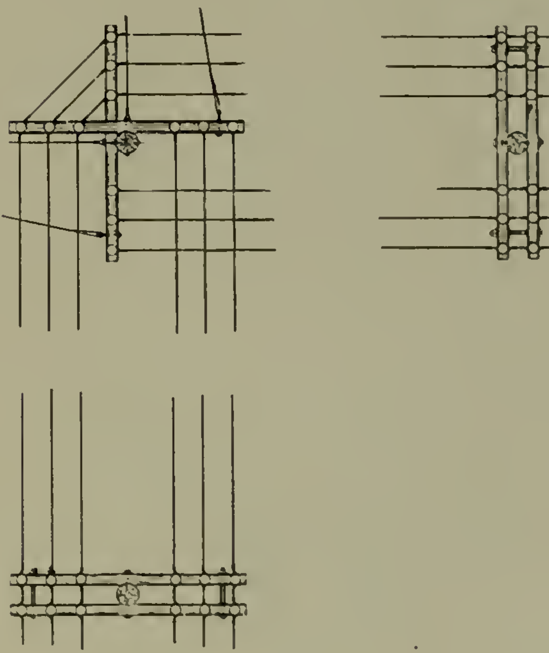


FIG. 14.—A CORNER POLE WITHOUT DOUBLE ARMS

be constructed, maintained, operated, and extended in a satisfactorily systematic manner. As series arc and series incandescent circuits are cut dead during the daytime, and will not, therefore, hamper linemen working on a pole, these circuits can often be run to advantage on the pole pins of a cross-arm. Such an arrangement is also convenient for making lamp loop connections.

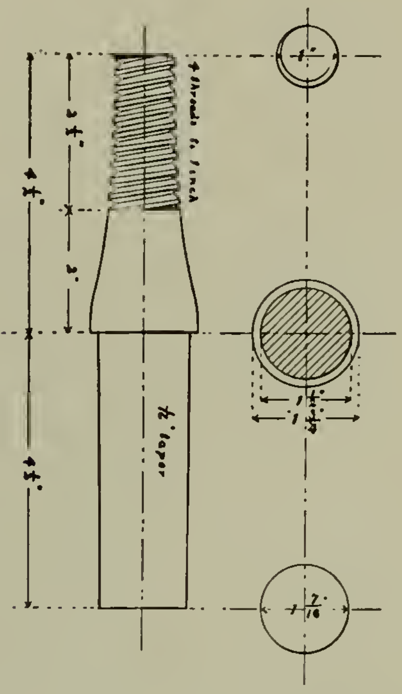


FIG. 15.—STANDARD LOCUST PIN

Multiple Circuits.—The wires of commercial circuits should retain the same relative positions on pins and cross-arms throughout their course, and should not jump from one set of pins to another set on the same cross-arm, or from one cross-arm to another cross-arm. To minimize the induction on alternating-current lines, the two wires of each circuit must positively be run on adjacent pins of a cross-arm. As these circuits are operated continuously day and night, 2200-volt circuits are preferably located on the adjacent pins at the ends of a cross-arm.

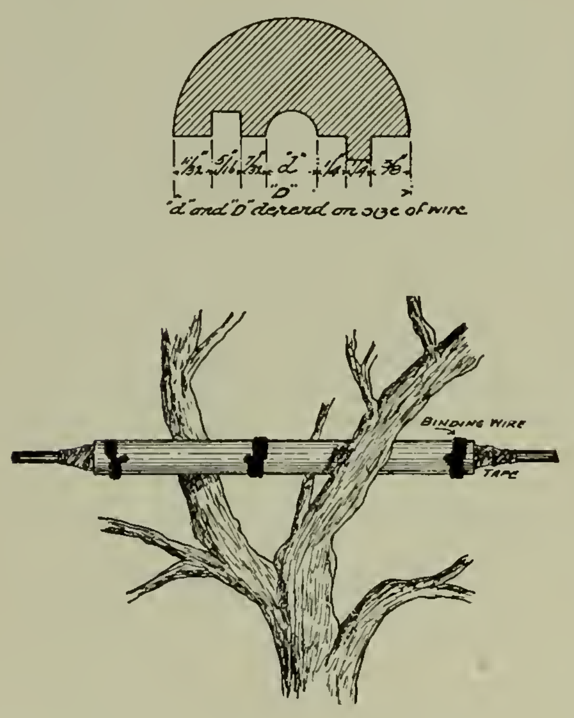


FIG. 16.—ABRASION MOULDING

To keep line work as straightforward as possible, and to simplify street lamp transformers and service connections, all through feeders are placed on the upper cross-arms of a trunk line, as far as possible, and all circuits feeding the territory through which the line passes are located on the lower cross-arms. Five-hundred-volt wires can often be advantageously located on the pole pins at the centre of a cross-arm.

Secondary Circuits.—Secondary mains should be run on the lowest or lower cross-arms, and preferably on the end pins of the arm nearest the side of the street on which the consumers are situated. If, however, secondary mains supply both sides of a street about equally, they should be located near the centre of the cross-arm. Secondary mains should positively be located on adjacent pins of a cross-arm, and three-wire mains located on adjacent pins and with the neutral wire in the centre.

SECONDARY DISTRIBUTION

Two-Wire Mains.—Where the service connections of two or more consumers are located within a radius of about 500 feet, they may be fed by the two-wire system of distribution from one centrally-located transformer.

Three-Wire Mains.—Where consumers are comparatively numerous in a given block or district, the secondary mains will be practically continuous, and three-wire secondaries should be employed.

Service Wires.—The service is that portion of the overhead system extending from the mains or transformer secondaries on the pole to the consumer's service outlet on the building. Service connections should not be made with wire smaller than No. 6 B. & S. gauge, except for spans of not more than 75 feet, and not crossing a street, under which circumstances No. 8 B. & S. gauge may be used. In all cases they should be of such a size that the drop from the transformer to the consumer's outlet, including the drop in secondary mains and service connections, shall not exceed 2 per cent. Duplex rubber cable may frequently be used to advantage for service connections where the spans are not excessive.

The regulation method of supporting wires on buildings should be by iron brackets, but with wires not larger than No. 6 B. & S. gauge, carrying not over 125 volts and running along straight, smooth walls, or along the fronts of adjacent buildings, and where there will be no strain on the supports other than that caused by the weight of the wire, approved glass knobs, attached to a building by screws, may be used. All exposed wires on a building that are within 8 feet of the ground should be enclosed in conduit.

Location of Transformers.—Transformers must be installed only on poles or in fireproof vaults, and should not be attached to walls, roofs or other parts of a building. When on poles, transformers should be hung on the face, or cross-arm side, of the pole. Transformers of 3000 watts' capacity or less may be hung at the most convenient location on the line cross-arm and immediately under the primary wires feeding the same. Transformers of over 3000 watts and up to 15,000 watts' capacity should be hung on the line cross-arms, and astride the pole, the hooks of the transformer hangers being attached to that cross-arm which carries the primary circuit feeding the transformer.

Transformers of over 15,000 watts' capacity should be hung astride the pole and on special cross-arms bolted to the pole below the line cross-arms. Transformers larger than 30,000 watts' capacity should not be hung on regular line poles. Double-arms may be used when they will make it possible to feed primary or secondary wires more directly from insulators to transformers than is possible with the single cross-arm.

Removal of Transformers.—Whenever a consumer discontinues the use of a service for a definite short period his service wires should be immediately disconnected from the line, and if he be supplied by an individual transformer, this should also be disconnected by removing the fuse plugs. If the stoppage be permanent, or for a long or indefinite time, the service wires, and the individual transformer, if there be one, should be entirely removed.

Underground Connections.—When transformers are to be located in basement vaults, the latter should be built by the owner of the building, in accordance with the requirements of the National Board of Fire Underwriters. The primary wires running down the side of the pole and underground to the vault should consist of an approved lead-encased twin conductor, carried through a conduit.

Pole Wiring.—All wiring on the pole and all apparatus on it should be so located as to leave one side, namely, the back of the pole, free for climbing and working upon. Therefore, all primary and secondary connections of transformers, branch taps carried across the pole on spreader brackets, lightning arrester connections, and all service connections, should be made on the face or cross-arm side of the pole. Also, twin conductors carried down the pole for arc or incandescent lamps, and cables and conduits for primary and secondary underground service connections, should be located on the face of the pole.

If it is necessary, in order to clear pole steps or cross-arms, that they be located toward the side, the location selected should be that quarter section of the pole lying between the pole face and the side toward the street curb. All wiring to and from fuse blocks and the primary line wires, or the transformer primary terminals, should be done neatly and securely, and with as little slack wire as possible. Wires should be run horizontally or vertically, and all corners turned with right-angle bends.

The use of duplex conductors for pole wiring is recommended as being both more sightly and convenient than single conductors. This is especially so where wires have to be carried down the side of a pole, and should be used in all such cases. Twin conductors, however, should not be used for primary constant-potential circuit pole wiring unless protected by pole cut-outs.

Fuse Blocks.—To protect both line wire and transformers, there should be inserted in each leg of a primary circuit, where the same connects to a transformer, a single-pole cut-out of an approved type. Such cut-out blocks should always be fused, and the fuse wire of a size to carry not more than 50 per cent. overload on the transformer.

Fuse blocks should be conveniently located on the cross-arm, preferably being placed immediately under the line to which they are tapped. A branch fuse or switch box of approved type should be placed on each leg of a circuit where a set of mains tap to the feeder wires, and also where important branch lines are tapped to the mains. Fuses should be of ample size to carry the normal maximum load on the branch which they protect, and of a size to open the circuit upon a severe overload or short circuit on that branch, without blowing the fuses on the feeder.

The use of branch cut-outs, as described above, is recommended, but not required. Local conditions of operation must be taken into consideration before deciding to locate branch cut-outs, and judgment used in placing them, as the indiscriminate use of such cut-outs might be a source of unnecessary interruptions to the service.

SERIES ARC AND INCANDESCENT LAMPS

Series Arc Lamp Suspension.—No method of suspension for arc lamps can be rigidly specified, owing to the various conditions and types of lamps to be covered. Whatever system of suspension is adopted should be neat, simple and mechanically and electrically secure. Lamps hung from a rigid support will be much less liable to open-circuit troubles than if their method of suspension allows of much swinging, and for this reason the use of span wires should be avoided.

When lamps must be so hung, the span cable should be a stranded iron or steel cable, and be fitted with a strain insulator at each end. The insulators will be located 6 feet from the supporting poles, as specified for guy insulation. Arc lamps should be suspended so that the bottom of the lamp will be approximately 20 feet above the ground, and when at such a height, the hanger insulator should be drawn close up to the tail pulley, but not touching it.

When manila rope is employed to lower the lamp, the lamp pulley should have some catch arrangement that will relieve the rope of strain. Every series arc lamp should be equipped with an absolute cut-out of approved type and have a double insulation between the lamp and the supporting rope or cable.

Series Arc Lamp Loop.—When the lamp loop runs down the side of the pole, and this method of construction is recommended as being both more sightly and reliable than when the conductors are suspended in the air, duplex conductor should invariably be used. This conductor should be No. 8 B. & S. gauge, and for arc lamps should have a rubber wall of not less than three-sixty-fourths inch and a covering of braid or tape on each conductor, and with a covering of braid over all.

The duplex conductor, as specified above, should be attached to the pole by means of standard deep groove, double-petticoat insulators on iron brackets, or may be run through an approved insulating conduit that is securely attached to the pole by means of metal clamps. If glass knobs or porcelain knobs or cleats be used, each conductor of the duplex cable should have a rubber wall of not less than three-thirty-seconds inch, and a covering of braid or tape on each conductor, and with a covering of braid over all.

A typical method of series arc lamp suspension that is recommended as being both neat, simple and mechanically and electrically secure, is shown in Fig. 19.

Series Lamps Attached to Buildings.—The use of series lamps in

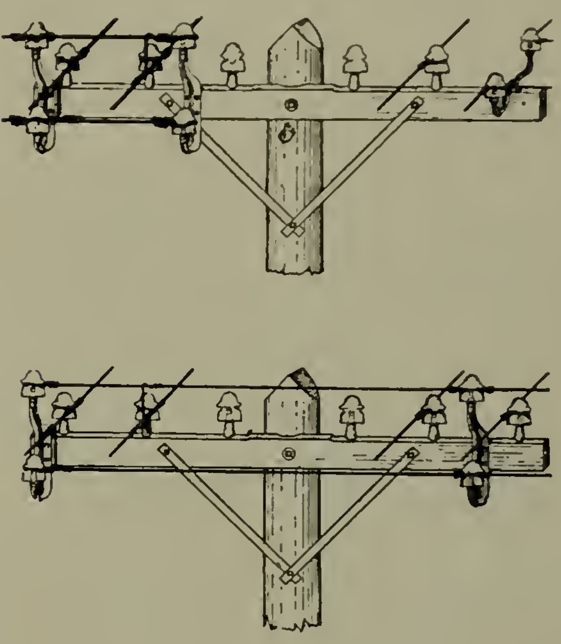


FIG. 17.—BRANCH LINE TAPS

buildings, or attached to buildings, should be avoided. Series arc lamps so installed must be located at least 9 feet from the floor, and in every way beyond the possibility of accidental contact by people in or about the place. They should be of a type having a ball-shaped globe enclosing the carbons, holders and the lower frame of the lamp.

The lamps, wires and all fixtures for series arc lighting in buildings should be installed by the company and in accordance with the rules and requirements of the National Board of Fire Underwriters. A switch of

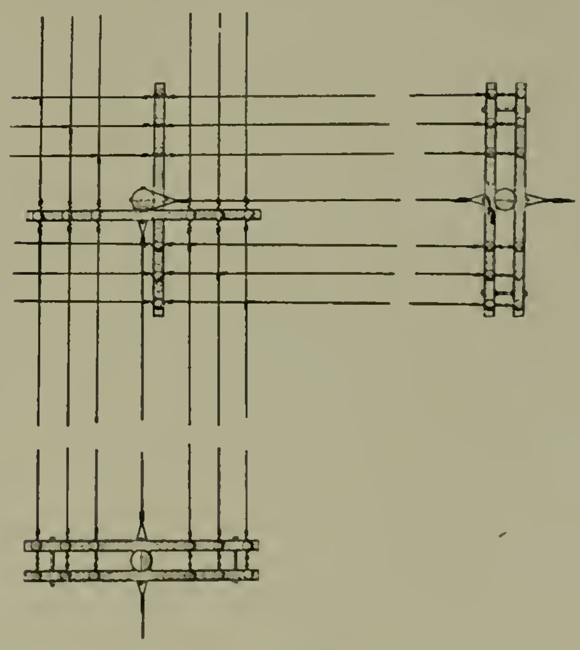


FIG. 18.—CORNER POLE WITHOUT DOUBLE CURVES

approved type that will cut off the current entirely from an installation should be placed at least 10 feet from the floor where the circuit wires are first attached to the building, and at a point at all times accessible from the street.

Series Incandescent Lamps.—Series incandescent lamps will be run on constant-current circuits controlled by some form of regulator, prefer-

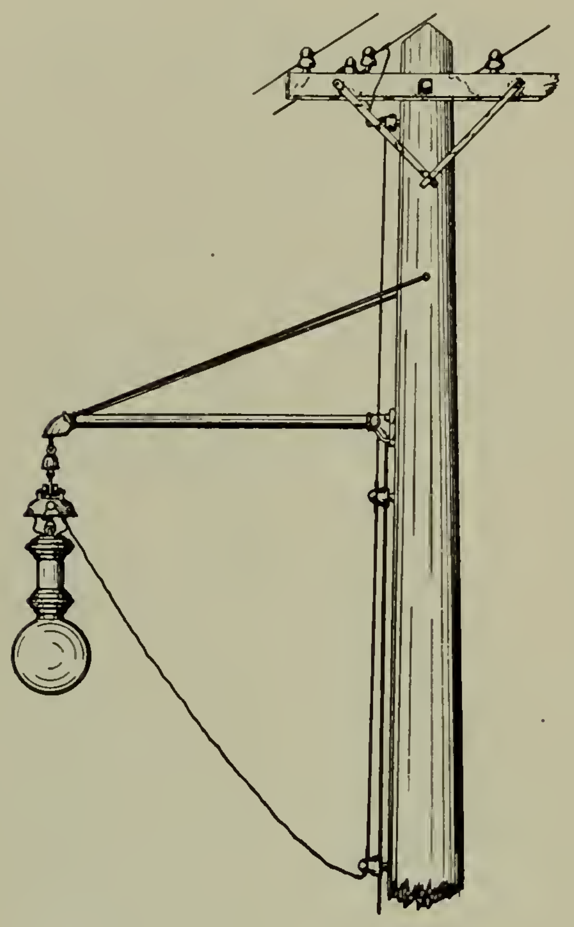


FIG. 19.—INNER ROPE ARC LIGHT SUSPENSION

ably automatic, located at the station or sub-station. It is recommended that shunt box or similar systems be not used. Each series of lamps should be run from the regulator on a separate circuit, common returns for two or more series being avoided, and the series circuits throughout should be electrically independent of the commercial service.

The lamps should be suspended from poles on fixtures of an approved type, having insulated heads, and lamp sockets with approved cut-outs. Fixtures should be of such length and so attached that the lamp will be 3 feet 6 inches from the pole and 14 feet above the street, unless otherwise specified by municipal contract. They should be firmly attached to the pole by means of two 4-inch lag bolts. If the series circuit to which an incandescent lamp is to be connected is on the same side of the pole as the lamp fixture, if there are no intervening cross-arms or line wires between the circuit and the fixture, and if the drop does not exceed 15 feet, the connection to the lamp may be made by dropping the No. 6 B. & S. line wires from the break-arm insulators in the circuit to the line insulators at the lamp end of the fixture, as in Fig. 20.

If the circuit is on the opposite side of the pole from the fixture, so that the wires installed as above would cross the pole, or if there are intervening arms or line wires, or if the drop would exceed 15 feet, then the connection to the lamp should be made by means of rubber-covered duplex conductors attached to the pole and installed as in Fig. 21. It is recommended that duplex conductors be used in all cases for series incandescent lamp loops.

GROUND CONNECTIONS

Grounds for Lightning Arresters.—When lightning arresters are to be placed on a pole, special attention should be given to making a good ground connection. A piece of No. 4 B. & S. gauge insulated copper wire should extend down the pole from the arrester location to a suitable ground, as hereinafter specified. This ground wire should be as short, straight, and free from coils or turns as possible, and run down the side of the pole enclosed, in a half-round wooden moulding. The moulding should extend to a depth of at least 6 inches below the surface of the ground. The part of the ground wire below the surface of the ground should be cleaned free of insulation. This ground wire is preferably carried under the ground in as direct a line as possible to the nearest service water pipe and connected thereto by being sweated into a lug attached to a clamp, the clamp being firmly bolted around the pipe. The water pipe should be cleaned bright before the attachment is made, and the clamp and part of the pipe adjacent to it painted with asphaltum paint after the connection has been made.

If no water pipe is available for a ground connection, the ground wire should be attached to a plate of No. 16 B. W. G. copper containing not less than $4\frac{1}{2}$ square feet of surface, and should be riveted and soldered securely to both surfaces thereof. If the soil at the base of the pole is suitable for a good ground, the pole hole should be dug 1 foot additional in depth, or if the pole is already set, a hole not less than 6 feet in depth shall be dug beside the pole, and a 6-inch layer of crushed charcoal or coke placed in bottom of same.

The copper ground plate should then be placed on the coke and covered by an additional layer of 6 inches of crushed charcoal or coke. If the soil at the butt of the pole is not suitable, the plate should be placed in a bed of charcoal or coke as specified above, in a hole which will furnish a suitable ground as near the pole as possible, the ground wire being run under the surface of the ground in as straight a line as possible from the foot of the pole to the ground plate.

Grounding of Low-Potential Circuits.—The neutral wire of three-wire, direct-current circuits should be grounded at the central station and also every 500 feet in overhead lines. The secondary systems of all distributing transformers should be grounded. This should preferably be done at each consumer's installation by a ground wire connection from the service outlet to the city water pipe system, as called for and described in the paragraphs covering the grounding of secondaries in the company's wiring rules.

FOREIGN LINES

Limiting Attachments. — Extensions to the company's lines should preferably be made by the erection of independent pole lines. Attachments should not be made to poles of foreign companies, even though there be agreements permitting joint use, unless the conditions for any

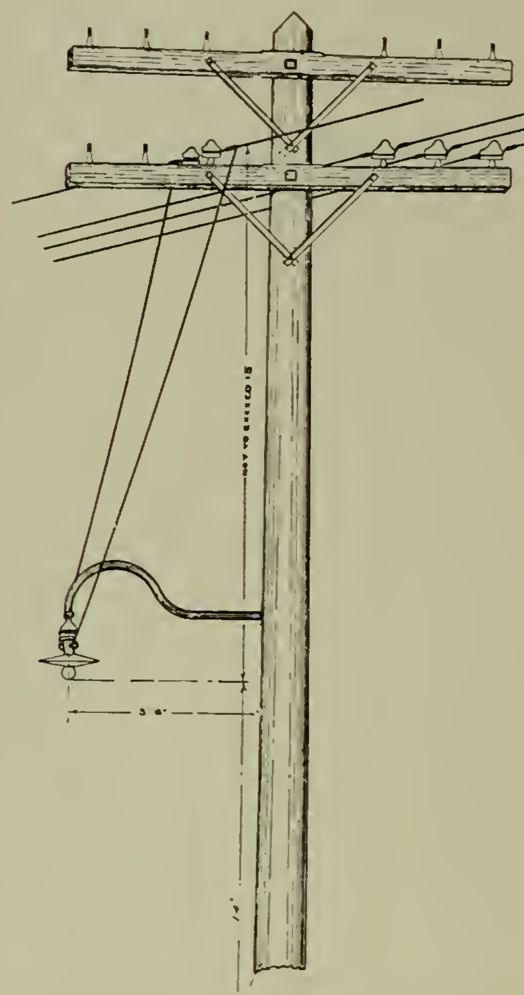


FIG. 20.—INCANDESCENT LAMP SUSPENSION WITH SEPARATE CONDUCTOR LOOP

particular extension make such attachments necessary, but joint occupancy is always preferable to parallel or conflicting separate pole lines on the same side of the street.

Independent Cross-Arms.—Foreign attachments should not be made to cross-arms carrying the company's wires, nor should wires of the company be attached to foreign cross-arms. The use of wooden bracket pins instead of cross-arms by foreign companies upon the company's poles should not be allowed, except that one bracket pin may be placed on poles set on private property, when this pin is for the purpose of supplying a telephone service.

Cross-Arms on Poles Carrying Foreign Wires.—On all poles where the company's lines are below those of a foreign company, ample space should be provided between the inside wires.

Location of Wires.—On all poles jointly occupied by the wires of the company and those of another, it is recommended that the company's wires be placed on the top cross-arms, and above all other attachments. A clear space of 4 feet (two gains) should separate the company's wires from foreign wires.

Foreign Cables.—Foreign grounded cables should be so installed that workmen cannot make simultaneous contact with high-potential wires and the grounded cables.

Interference from Lines of Other Companies.—In constructing overhead lines, careful attention should be given to avoiding any possibility of contact between the company's poles, lines or fixtures and the poles, lines or fixtures of other companies. It is not sufficient for the superintendent or line foreman to see that the construction on the company's poles and on jointly used poles is in good condition. It will also be necessary for him to see that the lines of foreign companies which are attached only to their own poles, but which are near to, or cross the company's lines, are so installed that there is ample clearance between the two lines and so that accidents are not likely to bring them in contact.

Guy wires and telephone services should be given particular attention. The superintendent should oppose any construction on the part of other companies that is likely to cause trouble to the company's service. Where there are two or more companies operating overhead lines in the same territory, the man in charge of the line construction of each company should recognize the fact that the presence of the other company's lines entails on him the necessity of so constructing the lines of his own company as to avoid possible interference or contact with the lines of the other companies.

Line superintendents should take up with the line superintendents of other companies in their territory all matters of construction where the overhead lines are likely to interfere with each other, and come to a mutual understanding as to the essential

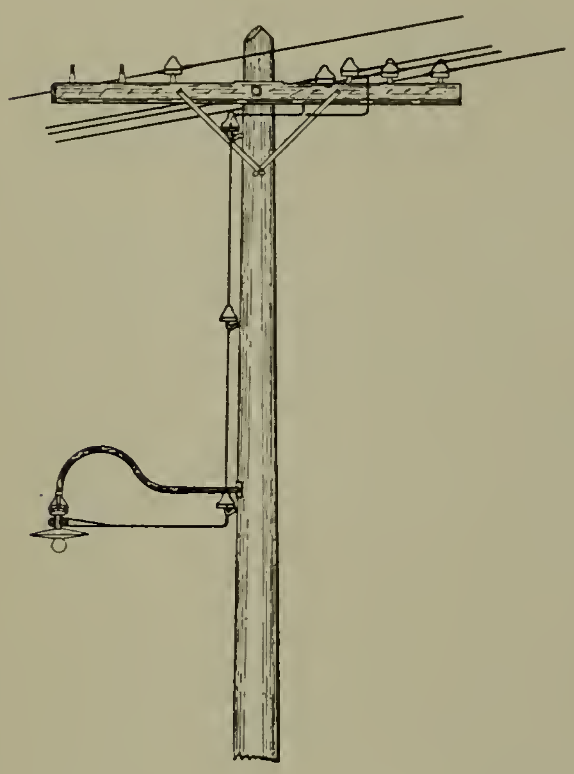


FIG. 21.—INCANDESCENT LAMP SUSPENSION WITH DUPLEX CONDUCTOR LOOP

points necessary to insure non-interference.

INSPECTION OF LINES

Every portion of the outside overhead construction of the company should be carefully inspected at regular intervals by an inspector detailed for the purpose, and where found to be in a condition, either through accident or decay, or from any other cause, that might make an accident of any kind possible, should be repaired at once, the repairs being carried out in accordance with these specifications.

This inspection must cover all poles, guys, lines, and line apparatus belonging to or operated by the company, either on public highways or on private property, and all attachments of the company on foreign poles. It must also cover the attachments, of whatever kind, made to the company's poles by foreign companies, and all conditions affecting, or likely to affect, the safe operation of the company's lines.

Any conditions found in the construction of a foreign company that might affect the safe and uninterrupted operation of this company's system should be immediately reported to the proper officials of such foreign company so that the same can be corrected. The inspectors should be supplied with suitable note-books or blank pads on which to note defects in the line construction of the territory covered, which should be turned in daily and immediately attended to by the repair department.

The Telephone as a News Distributor

An excellent example of the advantages of the telephone for distributing news, says "The American Telephone Journal," was recently furnished the people of Massachusetts on the occasion of the promulgation of the appeal of Governor Curtis Guild for contributions to the sufferers by the earthquake in California.

This letter of the Governor was read at a meeting of the relief committee and given to the telephone company at 5 o'clock in the afternoon and by 11 o'clock in the evening it had been dictated over the telephone and copied by the mayor, as the chairman of the board of selectmen, or his representative, in every one of the 356 cities, towns, villages and hamlets in Massachusetts except two, one being a mountain village in the Berkshires and the other a fishing hamlet on the island of Martha's Vineyard.

The letter was also given to the editorial office of every newspaper in Massachusetts during the same time.

This information reached the cities and larger towns in time to provide for calling special meetings of citizens and to be read before audiences already gathered together at theatres, concerts and other entertainments, enabling thousands to give twice by giving quickly.

Andrew Gray, in the Proceedings of the Royal Society, gives an account of the acquirements of magnetic properties by a Heusler alloy containing about 16 per cent. manganese, 8 per cent. aluminum, with a little lead and the remainder copper. It was originally almost non-magnetic. It was heated to 400 deg. C. in a furnace, and then allowed to cool slowly. After having been placed in a magnetic field it was found to have considerable residual magnetism. It was next heated to 340 deg. C. for about 20 min. and allowed to cool, when it was found that the magnetic properties were much more pronounced. The magnetic properties were destroyed by quenching from a temperature of 400 deg. C.

Direct-Current and Alternating Current High-Tension Transmission Compared

IT is proposed to transmit hydro-electric power in Italy from the Upper Adda River, in Valtellina, to Milan, a distance of 240 miles, and Signor I. Motta, of the Milan University, was requested by the City Council of Milan to report on the relative merits of the Thury direct-current transmission and that by alternating current. Approximately 28,000 KW. are to be delivered at the secondaries of the transformers in Milan.

The following abstract of the report is given in a recent issue of "The Electrical Review," of London:—

The comparison is made on the basis of 150,000 volts continuous current, and 60,000 volts alternating, three-phase current, these values being settled by consideration of the most economical voltage for each system.

The Thury system is to consist of ten groups, each group having four generators driven by one water turbine; the voltage per group is not to exceed a limiting value of 15,000 volts.

The transmission line is to have both positive and negative conductors, the earth not being employed as return. The centre point of the system is to be grounded. The 60,000-volt, three-phase scheme will consist of units operating in parallel in the usual way, with no novel features, the exact frequency to be determined later, but probably 42 cycles.

The costs of the two schemes work out, in round numbers, as follows, the estimates being based on machinery, switchboards, line insulators, poles, transformers for the alternating-current system and motor-generator transformers at the receiving end of the direct-current system. The cost thus calculated shows in favour of the direct-current system by 1.6 per cent., the figures being approximately $1,930,000 total for direct current and $1,960,880 for the alternating-current system.

A further comparison of interest is the division of the line and machinery costs into separate items, as follows:—

	Direct Current	Alternating Current
1. Machinery, including transformers, switchboards, etc.	$1,351,000	$723,750
2. Line, including insulators, poles, lightning arresters, etc.	579,000	1,236,130

The reason for this great difference in cost is stated to be partly the extra cost of the direct-current generators, but mostly the cost of the motor-generator step-down transforming units at the Milan end of the line; whereas in the alternating-current system only stationary transformers have to be purchased, which are comparatively cheap. The actual calculated cost of the machinery in the Milan (Thury system) sub-station is $694,800.

The following information on the calculated efficiency of the different systems is of considerable interest:—

Direct-Current System.—The over-all efficiency of the two systems shows in favour of the three-phase scheme by 3 per cent., the efficiency throughout being based on the full load of 28,000 KW.

The detailed efficiencies are as follows:—

	Per Cent.
Water pipes	96.5
Turbines	75
Generators	92
Line	95.3
Motors	92
Alternators for sectional distribution	93

Giving a total over-all efficiency of 54.2 per cent. for the Thury system.

Three-phase System.—The efficiency of the water pipes and turbines remains the same, while that of the line drops to 91 per cent., and the total over-all efficiency works out at 55.8 per cent.

It is of interest to note that one factor which has determined Consulting Engineer Motta to discard the further consideration of the direct-current system is that there would be 104 commutators in series on the line. The main conductors are, for the three-phase system, three wires, each of 240 sq. mm. cross-section, and for the direct current line four wires, two for each side, each of 140 sq. mm. cross-section. The costs given above include the interest on capital during construction, and the period of construction is assumed to be the same in each case. The final cost of energy to the municipality of Milan is calculated at $30.88 for the three-phase system per KW.-year, including all items; this cost is based on an assumed demand of full load continuously, that is, for 8640 hours per year.

This assumption of continuous load is perfectly reasonable when the conditions in Milan are considered. The traction system operates for seventeen hours in every twenty-four, and during the remaining seven hours an attempt will be made to persuade factories to operate by offering exceptionally cheap rates for power; it is noteworthy that already 3000 KW. are supplied in this manner every night by the present power company.

To carry the peak loads, an additional steam station, with a battery of accumulators, having a maximum output of 9000 KW. and an average of 4500 KW. for the whole year, is being considered for the near future, but no costs have been prepared yet for this scheme.

The report finally decides in favour of the three-phase system, partly on practical engineering grounds and partly from considerations of efficiency when operating at full load.

Electrical Time Service in Glasgow

A COMMITTEE appointed by the Glasgow Corporation to report on electrically propelled and electro-mechanical clocks, have, during the past year, examined the systems in use in Berlin, Antwerp, Paris, London, and other European cities, and also in America. Bids were also invited from a number of firms for a system of street clocks placed at forty-three points in the city, and for connecting thirty-two existing turret clocks to the proposed system.

It was estimated that such an installation would cost from $11,000 to $13,000, with an annual maintenance of from $2000 to $2750; for self-contained electro-mechanical clocks, the cost would be $24,500, with $3450 for annual maintenance. Connecting the existing clocks would cost $2400, with $200 for annual maintenance.

The committee considers that no system of public time service can be considered adequate unless the citizens are enabled to participate in the benefits of the scheme by renting electrical clocks. This would mean the instituting of a new department, which, for some years during its pioneering stage, might involve the city in a financial loss. The supply of time service presents in itself peculiar features which afford reasonable grounds for believing that at first this enterprise should be conducted by a private company. It is further suggested that at present the public does not adequately realize the importance of a precise time service to such an extent as would justify the Corporation embarking on an enterprise which would for some years be of an educative nature, in addition to performing its functions as a public utility.

It was recently reported that in a recent test by the De Forest Wireless Telegraph Company a 572-word message was sent across the Atlantic Ocean from Coney Island to the coast of Ireland,—3200 miles distant.

The Sale and Measurement of Electric Power

By S. B. STORER, General Manager of the Niagara, Lockport & Ontario Power Company

A Paper Read at the Recent Convention of the New York State Street Railway Association

SINCE the day when the first commercial electric light entered the field of artificial illuminants, there have been endeavours to find an equitable way of charging for energy supplied in the form of electricity.

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, and the ampere-houi meter, followed by various types of integrating and recording wattmeters, soon brought into use the idea of paying for the exact amount of energy used, at a given price per ampere-hour or per kilowatt-hour. This method is still in very general use in its simplest form, but there has been dissatisfaction with it from the time it started.

The fact of the matter is that neither the straight flat rate nor the straight kilowatt-hour rate is equitable except when applied in connection with a definite load factor,—and even then it may not be entirely so, due to uncertainty as to the number of hours per day that full-load conditions prevail, with correspondingly high efficiency, and to the hours during which operation continues at light loads with resultant low efficiency.

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. This has been shown in all classes of service,—incandescent and arc lighting, heating and power purposes, including railway lines,—and in power companies and consumers of all sizes.

Nor are power companies the only ones so affected by the load factor. No manufacturing company is entirely successful in the ordinary sense of the word unless it keeps all of its tools and equipment in use all of the time. No railroad can earn its full quota until it finds its tracks carrying their maximum number of trains every twenty-four hours, and every train carrying fully loaded cars throughout.

Robbed of unnecessary verbiage, it means that on every investment the interest, tax, insurance and depreciation charge,—commonly referred to as the fixed charge,—continues at a uniform rate over twenty-four hours of every day in the year, and unless the apparatus or material representing that investment is put to its maximum use every hour in the day and every day in the year, there is an opportunity for increase in efficiency until the theoretically possible condition of maximum use is reached. And the ratio of the use actually obtained to that theoretical or possible maximum use, is the load factor of the manufacturing establishment and of the railway line just as it is of the power house or transmission system.

Before taking up the question of rate-making and methods of charging, brief reference will be made to the cost of production of power from hydro-electric plants and from steam plants. In the former the cost is almost solely one of fixed charge, while the latter is made up from fixed charge coupled with variable items of coal, water, oil, waste, and incidentals.

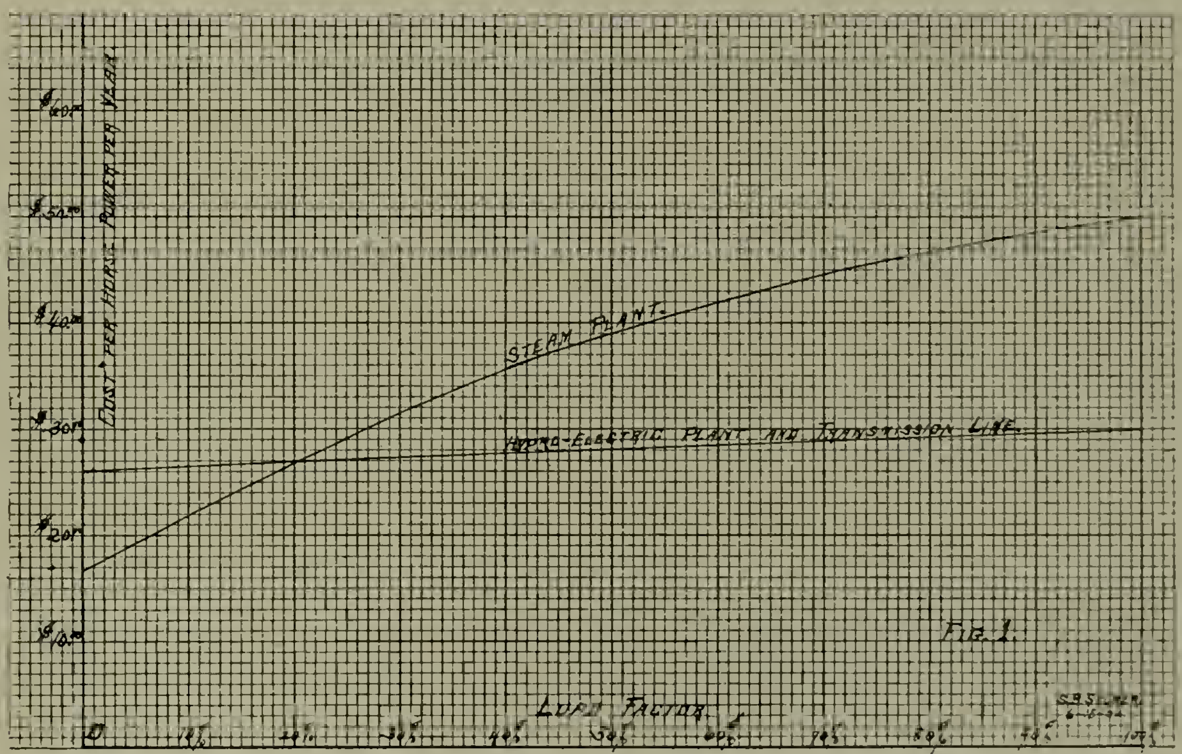


FIG. 1.—METHOD OF PLOTTING COSTS PER HORSE-POWER PER YEAR IN TERMS OF LOAD FACTOR, AND PRICE PER HORSE-POWER PER YEAR

With the hydro-electric plant, consequently, the cost per horse-power per year is almost constant, regardless of whether supplied one hour per day or twenty-four hours per day. Repairs are about the only variable, and they may be considered as increasing in direct proportion to the load factor. Labour, oil, waste, and the like, are nearly the same irrespective of the proportion of light loads to full load.

With the steam plant, on the contrary, the items of coal, labour, and others, increase rapidly with the load factor, and hence the cost per horsepower per year increases in almost the same proportion. The costs per porse-power per year may be shown graphically, as in Fig. 1, the curves being plotted in terms of load factor and price per horse-power per year.

The curve marked "Hydro-Electric" is intended to represent cost of power after transmission for some distance, while that marked "Steam Plant" represents cost at the powerhouse switchboard. These curves are about the best obtainable from any

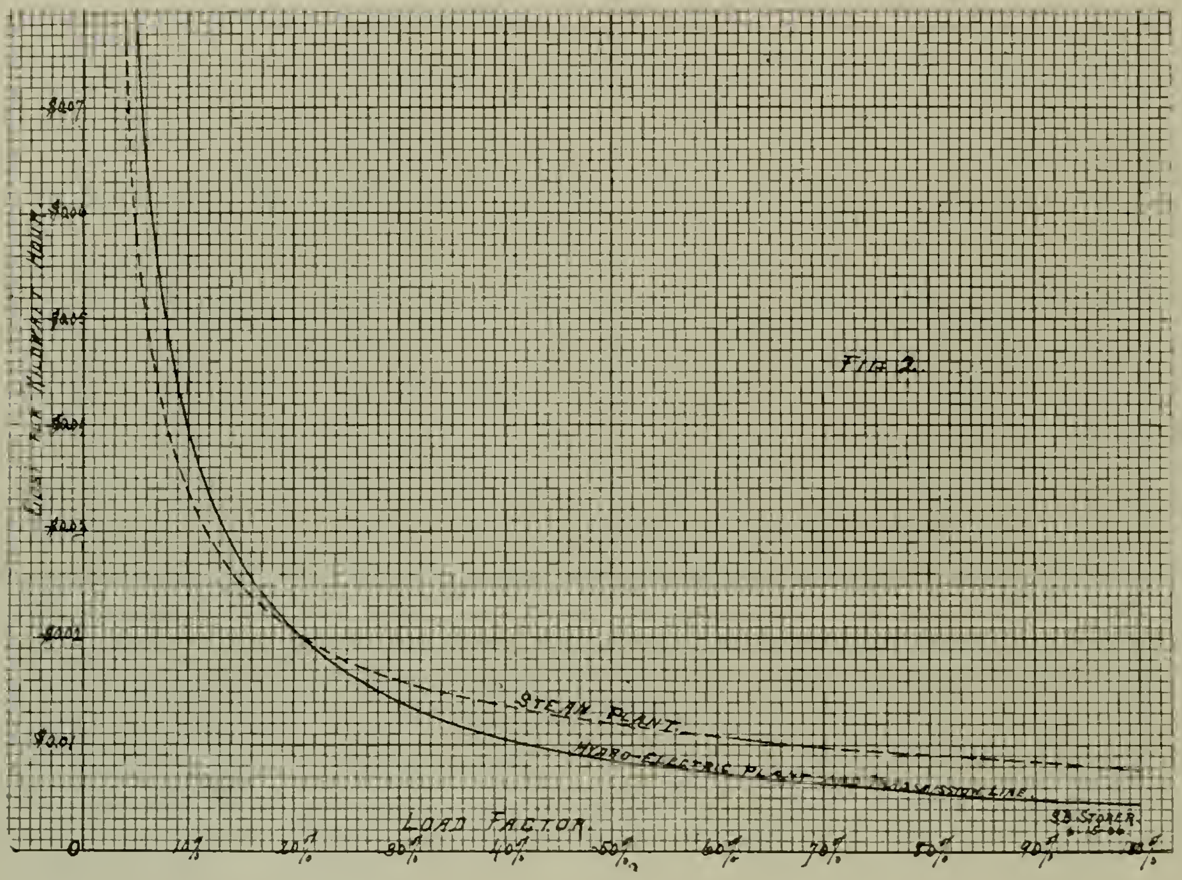


FIG. 2.—METHOD OF PLOTTING COSTS PER HORSE-POWER PER YEAR, IN TERMS OF LOAD FACTOR, AND PRICE PER KILOWATT-HOUR

power houses of 5000 to 10,000-H. P. capacity, with coal from $2.50 to $2.75 per ton.

In Fig. 2 the same costs are shown, but plotted in terms of load factor and price per kilowatt-hour. Particular notice should be given to the wide variation in cost per kilowatt-hour, ranging in the steam plant from nine cents at a load factor of 4 per cent. to about three-quarters of a cent at 100 per cent. load factor. The hydro-electric plant varies under the same range of load factors from ten cents to less than half a cent per kilowatt-hour.

In Fig. 3 is given a very convenient and easy method of changing cost per horse-power per year at various load factors to equivalent cost per kilowatt-hour or vice versa. The method to be followed in making the change is self-evident, so no explanation of it is needed.

If we now take up the case of a hydro-electric plant and transmission system with a wholesale cost of $30 per horse-power per year, and attempt to make a flat rate to all consumers, we quickly find there is little demand for power, as nearly every consumer has an intermittent load, or, in other words, a low load-factor, and cannot afford to pay or will not pay the price it is necessary to ask for flat-rate twenty-four-hour power. It then becomes incumbent on the power company to devise a system of charging that will not only enable it to market its output, but to do so at prices that will secure a net revenue for the power equal to $30 per horse-power-year, besides an additional amount sufficient to cover the cost of retailing or distributing it, but to further enable it to sell at rates low enough to be attractive to consumers. It is believed that the method described hereinafter offers a solution that is equitable to both power company and consumer, and at the same time gives the ordinary small consumer a low rate per horse-power per year, in spite of heavy distributing cost, and also gives the power company the necessary return on its maximum demand output.

In the proposed system everything is sold on a maximum demand basis, with the rate per horse-power per year varying between fixed limits in accordance with the consumer's load-factor. In order that this method may be clearly understood, mention is here made of the fact that the load-factor is computed on the basis of a twenty-four hour day; the kilowatt-hour consumption per day, divided by 24, being taken as the average demand, and dividing this average demand by the maximum demand for that day, we have a fraction,—or in one case unity,—representing the load-factor for the given twenty-four-hour period. In the same way the load-factor for any month may be obtained by dividing the average rate of consumption for the entire month by the average of the daily maximum demands, thus obtaining the average load-factor of all the days in the month.

The maximum demand is taken as being the highest rate of consumption for any one minute during the day; or, as it is perhaps more commonly expressed, the highest one-minute peak occurring during any day is considered as the maximum demand for that day. The average of these highest daily one-minute peaks occurring during any month

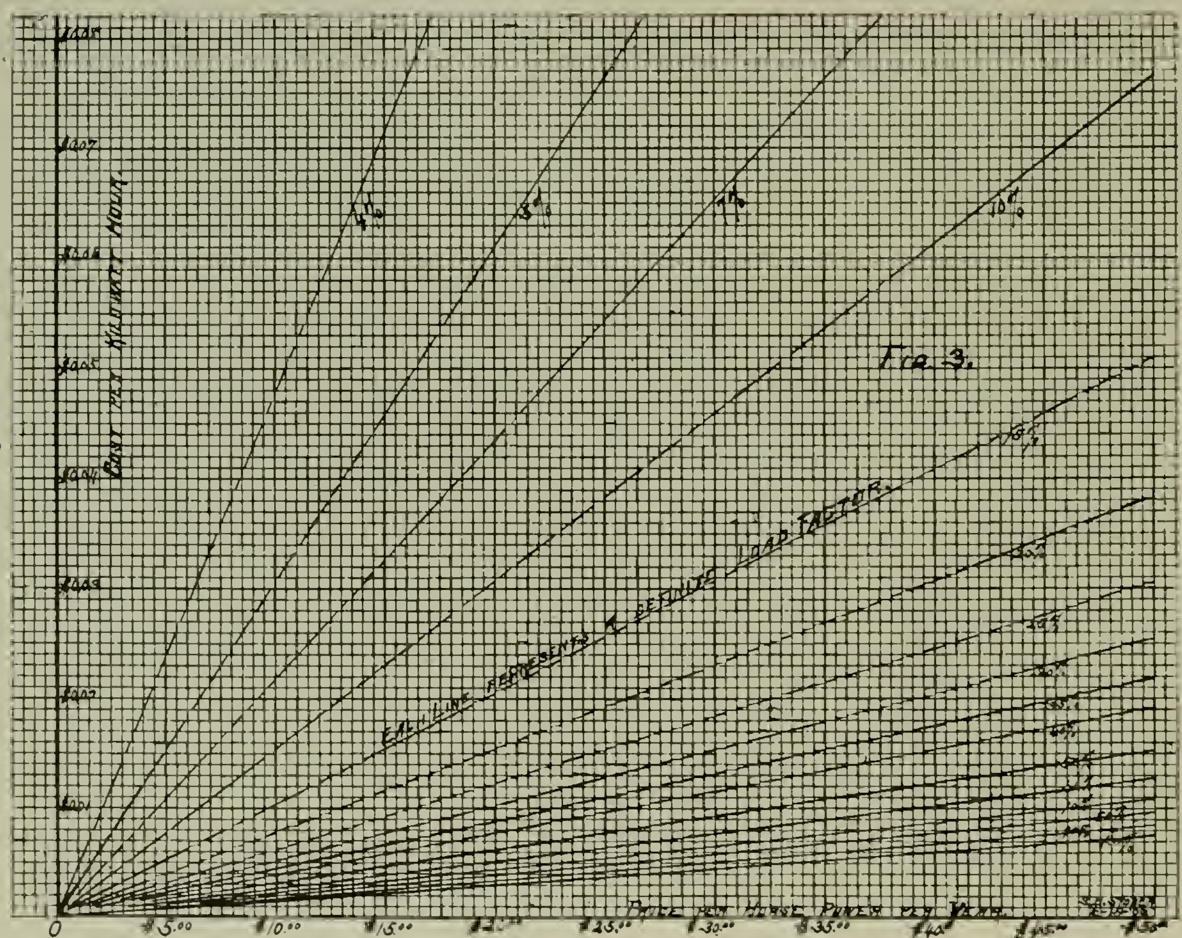


FIG. 3.—METHOD OF CHARGING COST PER HORSE-POWER PER YEAR, AT VARIOUS LOAD FACTORS, TO EQUIVALENT COST PER KILOWATT-HOUR, AND VICE VERSA

then becomes the average maximum demand for that month, and is so used in the calculation of load factor.

Assuming that a manufacturer has made a contract to buy 400 horse-power for the operation of his factory, and that the rate per horse-power-year varies between the limits of $16 and $43, depending on the load factor, the determination of his rate per horse-power per year for any given month would be as follows:—

If the kilowatt-hours consumed during a thirty-day month are 43,200, then the average demand for power is 43,200 divided by 720 (the number of hours in the month), equal to 60 KW. or 80 H. P. Assuming further that his maximum demand each day was just 400 H. P., then, of course, his average maximum demand for the month will be the same amount, and the load factor is 80 divided by 400 = 0.2, or, as commonly expressed, 20 per cent.

If the rate per horse-power-year varies between $16 and $43, it will be evident that the variable quantity is the difference between $16 and $43, or $27. The rate is, therefore, equal to the minimum rate ($16) plus the load-factor (0.2) times the variable ($27). Two-tenths of $27 is $5.40, so the rate per horse-power per year for that month will be $16 plus $5.40 equals $21.40. The total charge for the month would, therefore, be 400 times $21.40 divided by 12, or $713.33. This is equal to 1.65 cents per kilowatt-hour. If his use of the power had been such as to give a load-factor of 30 per cent., the rate per horse-power per year would have increased to $24.10, but the equivalent cost per kilowatt-hour would have decreased to 1.24 cents,—a reduction of almost 25 per cent. in cost per kilowatt-hour due to increasing the load-factor to 30 per cent.

This may readily be put in the form of an equation which, if the desired rate per horse-power per year is R

the minimum rate limit is A

the maximum rate limit is B

and the load-factor is L

is expressed by R = A + L (BA).

This method is much more equitable than that sometimes used, of selling all the power on a kilowatt-hour basis with a guarantee from the consumer of a specified load-factor. By referring to Fig. 4, there will be seen the diagrammatic equivalent of such a method of charging converted into a cost per horse-power per year basis. The example given there is that of a kilowatt-hour cost of one cent with a guaranteed load-factor of 30 per cent. This simply means that the consumer pays a flat rate per horse-power per year of $19.60 at all points from zero load-factor to 30 per cent. load-factor, inclusive, and from 30 per cent. to 100 per cent. load-factor the rate increases in direct proportion until it reaches the limit at $65.35 per horse-power per year at 100 per cent. load-factor.

This method is bad for both parties to a contract. For the power company, if we assume that any considerable transmission is involved, and that a relatively large amount of power is under contract to be delivered, the price of $19.60 per horse-power per year is too low to cover cost,—much less than necessary to pay a profit. There is also no probability that the rate will ever be much higher than this, as there is no inducement to the consumer to increase his load-factor above the guaranteed 30 per cent.

On the other side, the consumer

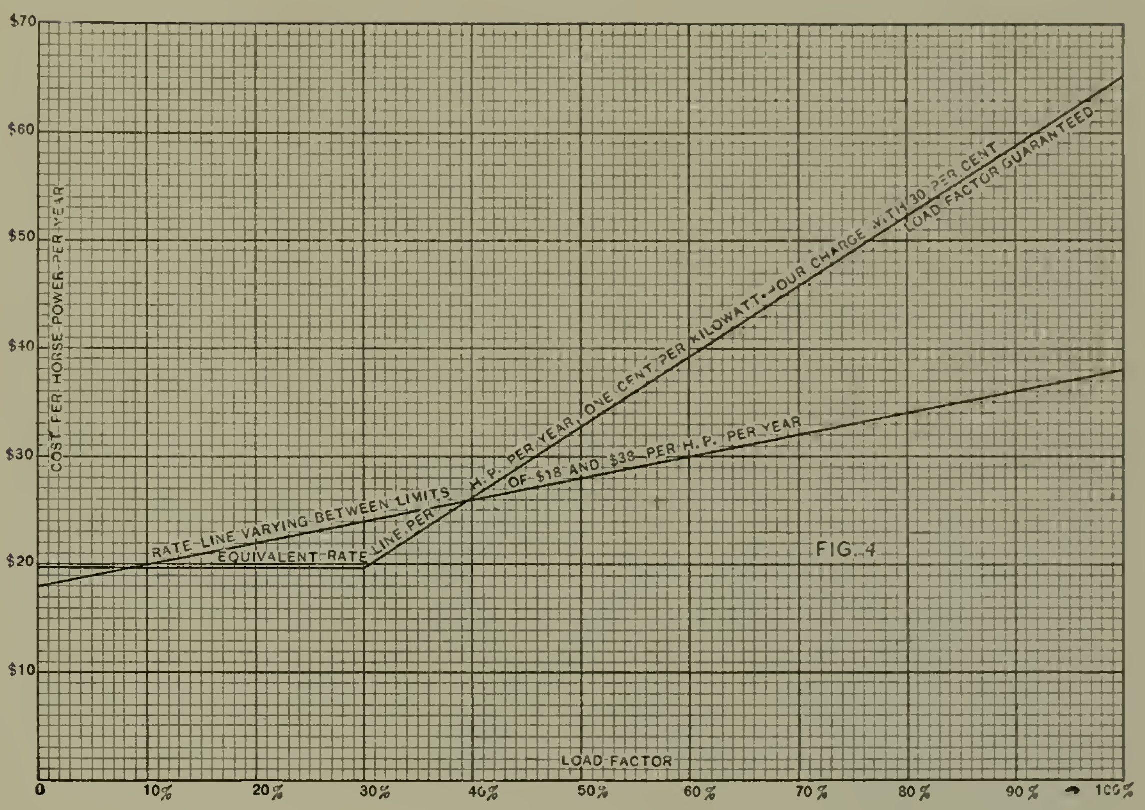


FIG. 4.—SUGGESTED PLAN OF CHARGING FOR ELECTRIC POWER

FIG. 5.—EQUIVALENT KILOWATT-HOUR CURVES OF HORSE-POWER PER YEAR CURVES SHOWN IN FIG. 4

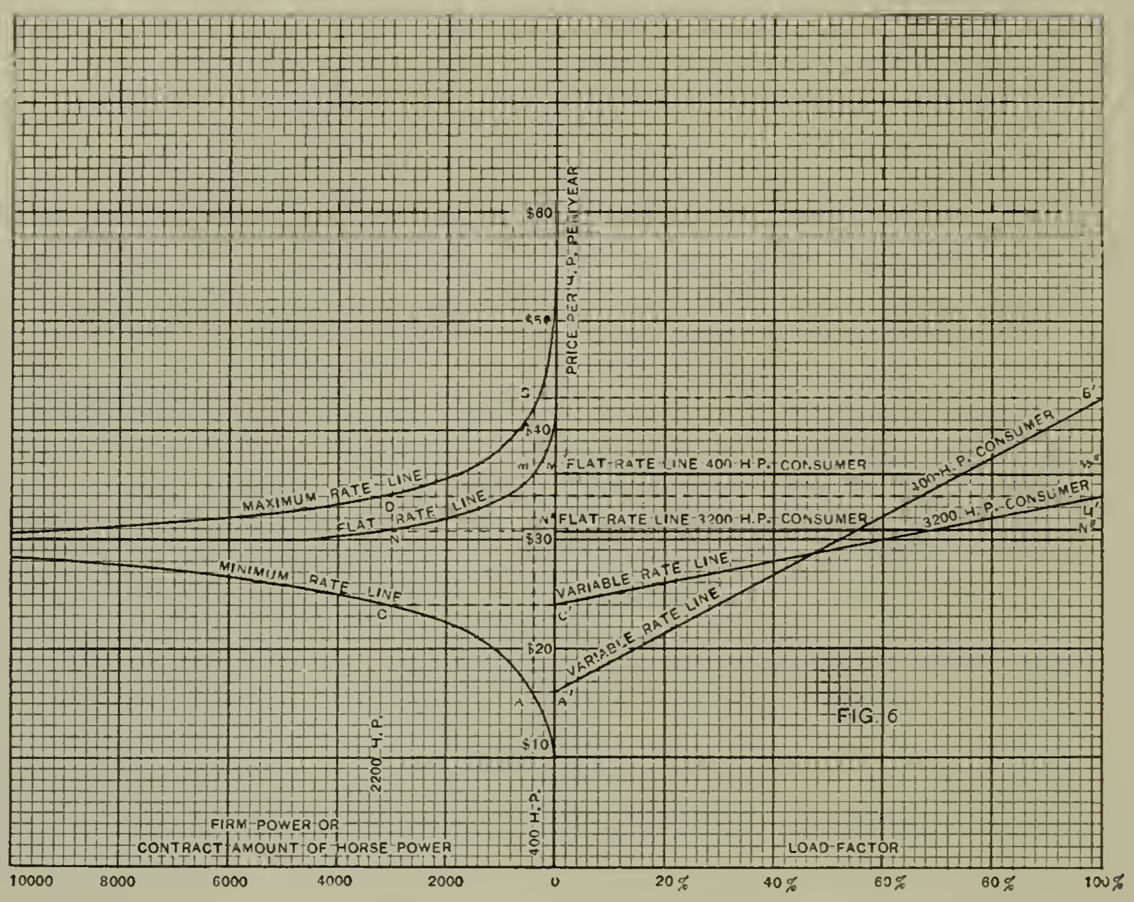


FIG. 6.—SHOWING RESULTS UNDER THE SUGGESTED PLAN FOR CHARGING FOR ELECTRIC POWER

has a right to assume that the price at the guaranteed load-factor offers a fair return per horse-power per year to the power company, and consequently no effort is made to increase his load-factor, particularly as his cost per kilowatt-hour remains the same. If, however, the contract is one of long duration, and, due to natural causes beyond control of the consumer, the load-factor should increase to a high value, say 75 or 80 per cent., the consumer would be paying over $50 per horse-power per year for power that he is justified in thinking does not cost over $20 or $25.

A better way of charging,—certainly a much more equitable way,—would be to sell the power on a maximum-demand basis with the rate varying between the limits of, say $18 and $38 per horse-power-year,—this rate-line also being shown in Fig. 4. With this way of charging there is a continual inducement held out to the consumer to increase his load-factor. The power company would probably also increase its profits somewhat by the increase in load-factor, but only to a comparatively small extent.

In Fig. 5 the two curves of load-factor and cost per kilowatt-hour are given, and they indicate more clearly than words the advantage of the system having as its basis the load-factor of the consumer. The dotted line represents the one cent per kilowatt-hour rate with a guaranteed revenue equal to that from a 30-per-cent. load-factor consumption; the full line or curve gives the equivalent cost per kilowatt-hour of the variable $18 to $38 per horse-power-per-year rate.

With such a system of charging established, the question immediately arising will be as to the manner in which the limiting values per horse-power per year are established, with power companies of different capacities to supply demands of all kinds and sizes.

Referring to the assumed case of a hydro-electric plant and transmission line wherein the wholesale cost is $30 per horse-power per year, and further assuming that the rated capacity of the system, as a whole, is 10,000 horse-power, we then have a basis with which to start. In Fig. 6 a vertical line is drawn from the zero point at the middle of the lower line, and laid off in price per horse-power per year. On the lower line to the left is laid off the amounts of power that may be sold, up to the capacity of the plant. To the right is laid off the load-factors that may be obtained by the various consumers. From the $30 point on the vertical line a horizontal line is drawn to the left that may be known as the "base-rate line."

If power is to be furnished to consumers having a load-factor of approximately 100 per cent. and sold on a straight flat rate per horse-power per year, then the cost of retailing the power in small amounts will increase the cost as the amounts decrease, approximately in accordance with the curve starting from the base-rate line on the 4400-H. P. point, and increasing to $43 on the zero horse-power line. If the consumer takes anything over 4400 H. P., he may be considered as being entitled to the wholesale rate of $30 per horse-power per year.

If, however, the consumers operate at a low load-factor, the power company may "oversell" its plant to an extent directly dependent on the relation between the capacity of its plant and the amount of firm power sold to each one. The amount it may be oversold may be determined approximately from the equation of the "Law of Probability," or graphically from the "Probability Curve," both of which may be found in books on higher mathematics, but which will not be taken up here, as this is not intended to be a treatise on that subject.

It may be said, however, that if a large number of motors are operating in a city, performing all classes of work, starting and stopping, running part of the time at full load and part of the time at light loads, the ordinary amount of power required to supply them will be much less than the total rated capacity of the motors, and still every one of the motors may at some time during the day have been operated at full rated load. As a matter of actual practice, the ratio is about three to one, the motors, of course, being mostly of from one-quarter horse-power to 20 or 30 H. P. The 10,000-H. P. plant could, therefore, safely connect on its circuits small motors having a total rated capacity of 30,000 H. P.

The average load-factor of the different installations would not be much, if any, over 15 per cent., and where occasional large installations are operating somewhat more uniformly, the load-factor would reach perhaps 25 per cent., it being assumed, of course, that they are practically all ten-hour factories. To such factories, of say 400 H. P. capacity, the power house could not be oversold more than twice. If the entire output were sold to one, two, or even three large consumers, the plant could not be oversold at all, as the chance of both or all three of the consumers taking their maximum of power at the same time is so high as to become almost a certainty. With a single 10,000-H. P. consumer there is no "chance" about it, and such a customer must pay the full flat rate of $30 per horse-power per year, regardless of load-factor.

In Fig. 6 the curve marked "maximum rate line" is an approximation of the "probability curve," drawn with reference to the $30 base-rate line and the central vertical line.

The curve marked "minimum rate line" is also an approximation of the "probability curve," drawn with reference to the same line, but on the lower side of the $30 base-rate line.

The minimum rate or the zero load-factor rate for any amount of power may now be found by following the vertical line from the desired amount of power indicated by the figures at the bottom line of the diagram until it intersects the minimum rate line. From the point of intersection follow the horizontal line to the right of the vertical line at the middle of the sheet, thereby obtaining the amount in dollars per horse-power per year. In the same way, from the intersection of the vertical line indicating the horse-power with the maximum rate line, the amount of the maximum rate per horse-power per year is obtained.

Taking as an example a 400-H. P. consumer, the intersections are found to be at *a* and *b* on the minimum and maximum rate lines, corresponding to $16 and $43, respectively. Carrying a horizontal line to the right from *b* to *b'* on the 100 per cent. vertical load-factor line, and connecting *a'* and *b'*, we then have a variable rate line for 400-H. P. consumers. The rate for consumers desiring to buy on a straight flat rate, regardless of load-factor, is obtained from the point *m* where the 400-H. P. line crosses the flat-rate line, or at the $36 point.

In the same way a 3200-H. P. consumer's variable rate would be from $24 to $34, with a corresponding flat rate of $30.40, and the variable rate line runs from point *c'* to *d'*.

Referring to the small consumers having a load-factor of approximately 15 per cent., and following the same method given above, ascertaining that the variable rate is from $11 to $52,—at 15 per cent. load-factor the rate would be $11. + .15 ($52.— $11) = $17.15.

In view of overselling three times for this class of consumers, the gross income derived for each horse-power actually delivered from the plant would be three times $17.15, equaling $51.45, or practically the maximum rate. This increased return per horse-power output at the station, over the corresponding straight flat-rate price of $41 per horse-power year, is made necessary by the fact that three installations must be made to get the gross revenue of $51.45, while only one is required for the $41 revenue. The difference in revenue is, therefore, just about sufficient to make up for this additional expense.

In the same way, the 400-H. P. consumer with a load-factor of 25 per cent. would pay at the rate of $22.75 per horse-power per year, and overselling twice would bring in a gross revenue of $45.50 per H. P. per year.

The combination of these two rate curves, both approaching the $30 base-rate line as the firm power increases, taken in conjunction with the method of charging that depends on the load-factor of the consumer, furnishes a system that affords absolute protection to the power company, and at the same time gives all consumers every benefit of low price that can be done with safety to the vested interests of the power company. Each consumer would pay a rate per horse-power per year such as to give the power company a uniform percentage of profit on all its business, so there could be no question as to "preferential rates" and certain consumers having advantages over others.

It may be said that the maximum demand is hard to measure, but with a demand for that class of meters there will come an instrument capable of fulfilling the requirements. For the most part, in small installations, the maximum demand may be taken as the rated capacity of apparatus installed, and an ordinary integrating wattmeter giving the kilowatt-hour consumption per month, for use in determining the load-factor, is all that will be required. With large installations, where greater accuracy is required, more money may be spent on individual measuring instruments with no relative increase in cost of meters over that of the many small consumers, and the total error in records would probably be very much less than under present service.

In the sale of power on the maximum-demand basis, the question of the amount of firm power to be taken, and the permissible demands above that amount, are always the subject of much discussion. In this system, however, intermittent demands in excess of the firm power may be permitted in percentages approximately those obtained by following about the same curve as the maximum rate curve,—measurement being made from the $30 base line up to the curve. For example, the small consumer may be permitted to take power 100 per cent. above his firm amount; the 2000-H. P. consumer, allowing for probable maximums occurring at the same time, would be entitled to about 25 per cent. intermittent demand. At the 10,000-H. P. limit, no intermittent demands could be permitted, as there is nothing with which to furnish them.

It must be understood, of course, that all permissible intermittent demands are paid for at the same rate per horse-power per year as the firm power, and are to be measured by the highest, daily, one-minute peaks, or average one-minute demands in excess of the firm power. The one-minute peak is taken for the reason that any load lasting for a full minute means a definite and corresponding opening of the gates controlling the water-wheels, and, therefore, limits their output as much as if it lasted a much longer time.

It is not to be expected that this system of charging,—based, as it is, on the "Law of Probability,"—will apply where only one class of service is supplied, as, for example, incandescent lighting. There is very little "probability" about that service, for people want the light when it is dark, and the demand consequently comes at that time. Where, however, lighting is only one of many other uses for power, the system indicated above applies with equal force, and may be used for every consumer, regardless of size or of the use to which the electric energy is put, and also of the number of hours per day it is supplied.

The same system may also be applied to steam plants if consideration is given to the range in cost due to change in load-factor. The modification would appear in Fig. 6 by using two base-rate lines, one at about $20 and the other one at about $55. The minimum and maximum rate curves would then be drawn with reference to these two lines, leaving a considerable variation in price per horse-power per year between zero and 100-per-cent. load-factor even for the largest consumers.

Greater leeway as to permissible intermittent demands could also be given, due to steam engines being capable of temporary overloads to a much greater extent than are water-wheels. The general principles underlying all power plants of whatever type are, however, the same; and one system of sale and measurement of their output, giving due considerations to local conditions, would, if universally used, do much to establish a better relationship between producer and consumer,—if, as in the one proposed, it is founded on equity.

On a recent trip, the Cunard liner "Campania" was in communication by wireless telegraph with Poldhu, in Cornwall, when 2350 miles from the British coast. At 1850 miles out, messages were received from both Europe and America.

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Leading Articles

The Neglected Boiler Room

On page 81 of this issue, H. T. Hartman pleads for better care and more consideration of the boiler room of power plants. It is true, as he says, that while there are many notable exceptions, in a large number of plants the boiler room presents an uninviting contrast to the other parts of the station. The direct cause for this is the fireman, careless, untidy, and drawing "the munificent salary of 14 cents an hour." The indirect cause, however, may be traced back to the lack of care in getting a proper man. One low in the scale of intelligence is generally neglectful of his personal cleanliness, and, what follows, neglectful of his work and the cleanliness of his surroundings.

That the selection of a fireman is a matter on which the economical operation of the power station depends largely, has already been emphasized by others. Last year, at the Denver convention of the National Electric Light Association, W. P. Hancock, of the Boston Edison Company, spoke of the firemen as those of the force who must be selected with care, for the type needed must have had experience, and must have judgment and be reliable. "We want men who will burn coal," he said, "and not simply dispose of it; men who will use judgment in both firing and cleaning fires.

"Firemen are a class of men who must of necessity do very hard work, and they are also a class of men upon whom the power stations are to a large degree dependent for their continuous operation. Both of these facts should be taken into careful consideration, especially as to the treatment of these men, and as to the wages paid them."

As to keeping the boiler room clean, he said:—"A little spare time on each watch, especially on Sundays and holidays, when the load is below normal, can be used in a manner not to cause reflection as to expense and, at the same time, make even the men who work in the room feel a sense of content, while a like feeling could not obtain in a fire room which contained the dirt and filth of months of accumulation, with no prospect of its ever becoming any better."

One of the ways suggested by the author in which labour cost might be reduced, is to provide means of getting the coal into the boiler room so that the fireman's time will not be taken for this work. One arrangement in use by some plants is to run the railroad siding alongside of the boiler room at such a height that the coal may be dumped into bins under the track and opening into the boiler room.

The author's statement that he has known the methods of different firemen to make a variation of 40 per cent. in the amount of fuel burned, emphasizes the importance of the personal equation in the problem of efficient fuel combustion. How can a fireman be shown that he is burning coal inefficiently? As is well known, poor combustion of coal results in loss of heat units to the stack. If, then, some means be provided to indicate this loss and show the fireman that he is burning the coal inefficiently, it will go a long way toward solving the problem.

With the ordinary method of flue gas analysis, however, the results are obtained so long after the test that the fireman cannot remember exactly the conditions and appearance of the fire at the time of the test. There is now in use, however, an automatic continuous CO_2 recorder, which seems to have met the conditions of rapidity of record and reliability. This apparatus has already been described in The Electrical Age, so that no particulars of its working need be given here. It will be interesting, however, to refer to the results obtained with this apparatus, as given in a paper read before the American Institute of Electrical Engineers by H. G. Stott, superintendent of motive power of the Interborough Rapid Transit Company, of New York.

Records taken from a stoker boiler while the recorder was covered up to prevent the fireman seeing it, and other records taken from the same boiler while the fireman was watching the CO_2 indications, showed a saving of more than 12 per cent. in the latter records.

One objection to the automatic CO_2 recorder might be that its cost, —$375 f. o. b. docks, New York,— would prove too much for small plants, where one would be necessary for each stack. It would seem, however, from the percentage of saving given by Mr. Stott, that the apparatus would soon pay for itself. It has been suggested that one recorder might be used for several stacks, being connected from one to the other by means of a system of tubes. This might result in a boiler being fired efficiently only when the recorder was on its stack, but it would, nevertheless, mark the beginning of a commendable improvement in boiler room equipment.

Electricity in the Drug Store

THE retail drug store offers a field for the utilization of central station current which ought not to be overlooked. Electricity is now used for lighting in a great many such establishments, and the small motor is gradually becoming better appreciated in this line of work. Outside the large cities, however, gas lamps of the Welsbach or open flame types, and even kerosene oil lamps, are widely used for drug store illumination. Where central station current is available at fair prices, there ought to be little difficulty in introducing electricity for quite a variety of drug store service.

There is probably no branch of artificial illumination which offers a better field for the trial of original ideas than the lighting of show windows, and the variety of wares carried by the modern druggist lend themselves especially well toward exhibition in high quality light. Fancy papers, glassware, silverware and toilet articles never appear to better advantage than under the soft yet brilliant illumination of the incandescent lamp, whether the high efficiency unit, the Nernst glower, or the ordinary frosted bulb be employed. Given an adequate supply of incandescent light, the gas-lighted drug store is always certain to look less attractive and be less comfortable in hot weather than its electrically supplied rival. For general drug store illumination the enclosed arc lamp with a diffusing reflector is being successfully used, but there is not much doubt that the most pleasing results can be secured by the use of incandescent lamps.

The extent to which the small motor can be utilized as an auxiliary in drug store service is far from realized by many central station men. The use of electric fans for ventilation, for keeping the window panes clear from frost and for operating coloured streamers of ribbon in window advertising, is familiar to everyone, but there are still many drug stores where motor-driven shakers for the soda fountain are unknown. Large stores often freeze their own ice cream, and the cost of doing this by an electrically-operated freezer is far below the cost of performing the task by manual labour.

Small centrifuges for separating cream and other liquids, ice crushers, grinders, pumps, and small lathes are made many times more convenient by the motor drive. A motor-operated pill-making machine is one of the latest devices for drug store work, the only thing necessary for the apothecary to do being to supply the hoppers with the ingredients in bulk. Moving window advertisements of all sorts are now in use in some of the larger drug stores, and in almost all cases the small motor is the power behind the screen.

Electric cigar lighters, sign flashers, small basement hoists and elevators, special electric heating apparatus for chemicals and electric signs in a multitude of varieties are worth considering by the central station man and the druggist. In many cases an electric refrigerating plant can be employed to great advantage on the premises.

The drug store offers a long-hour and sometimes an all-night load, and while it is seldom possible to install a great variety of equipment at the outset in such establishments, it ought to follow in due time that a persistent campaign in this field will be thoroughly profitable to both the central station and the druggist.

The Value of the Study of Electricity to Artillery Officers

THE full defensive powers of our modern seacoast fortifications, which have cost the United States Government nearly $98,000,000, have been made possible only by the application of electricity,-says Lieut. F. T. Hines, in the "Journal of the United States Artillery."

From the report of the Secretary of War for 1904, it is estimated that about $54,000,000 will be required to complete the fortifications of our proposed coast defense. Upon this assumption, it is safe to say that the total cost will reach $150,000,000. The electrical installation of this defence will cost approximately $5,000,000, or 3⅓ per cent. of the total. This amount is represented in our seacoast forts by electrical apparatus with the necessary accessories, such as boilers, engines, both steam and oil, dynamos, motors, storage batteries, telephones, searchlights, and telautographs.

If we should do away with this equipment, or discard its electrical features, says Lieut. Hines, our modern armament, or rather the effective use of our large calibre guns, on which the safety of the coast of the United States depends in case of war, would be impaired to at least half of its value. Eliminate the electrical appliances, the range finders, telautographs, and other apparatus now utilized in fire control work, and the efficiency of our coast defense will be depreciated nearly 75 per cent.

This may seem unduly to enlarge the value or importance of electricity, yet suppose in action the generators or engines failed to do the work or the storage battery fails to light the emplacements, or the telephones and telautographs fail to convey orders and ballistic data, what then becomes of our system of fire control or direction? In connection with this it may be assumed, in nine cases out of ten, that the failure of the foregoing apparatus to work properly is due to unskilled attendants or lack of careful care and preservation.

We cannot and should not expect an enlisted man receiving $13 per month, or even an electrician sergeant on his small salary of $40 per month, to give this equipment the care and attention required for its preservation and efficient operation without at least being properly instructed by officers over them, who in a measure are more adequately compensated.

To enable officers to give the necessary instructions, requires them first to prepare themselves properly for this work by a diligent and careful study of the subject of electricity and its many applications. Not only should all artillery officers be able to install and operate the instruments and equipment of the modern fortifications, but they should also be familiar with so much of the theory of electricity as bears directly on their work. This does not seem to be a very unreasonable requirement, when one considers that the enlisted men of the Signal Corps, electrician sergeants, and master electricians, must all possess this practical and theoretical knowledge, in a certain degree, in order to perform their daily duties efficiently.

The Chief of Artillery, in his report for the year 1901, found it necessary to make the following recommendations:—

"It is recommended that the employment of expert civilian electricians be continued, one for each Artillery District."

With the aid of our service schools at Forts Monroe and Totten, and the assistance of well-qualified master electricians, it is hoped that in the future reports from the same source it will not be found necessary to call upon the civilian electrician to assist the artillery in any other than work connected with the first installation. The chief reliance for the proper care and operation of our electrical installation must be obtained from the commissioned personnel of the artillery, assisted by properly instructed and qualified enlisted attendants.

The direct handling of this equipment must, of course, be intrusted to specially trained and efficient attendants selected by officers in charge of such work.

A New Timber Preservative

AN interesting method of applying a preservative to railway ties and timber is described in "L'Industrie Electrique," of Paris. The process consists of the artificial metallization of the pores of the wood, the metal being deposited electrolytically.

In brief, the method requires first the application of a solution of some salt, sulphate of copper, for example, by placing the wood immersed in the solution in a closed chamber and subjecting it to pressure. The wood is thus thoroughly impregnated with the solution. It is then taken out and piled up in layers in a concrete reservoir. The first layer of timber is immersed in the same copper sulphate solution and also rests on a layer of jute or other fibrous material which is supported by an electrode made of woven strands of copper. Similar electrodes are placed between each layer of timbers as they are piled up to the desired height.

Alternate electrodes are then connected to the opposite poles of an alternating-current supply, and the current is allowed to pass. The action is said to decompose the solution and set free metallic copper in the pores of the wood. Besides the preservative action in thus closing the pores, it is said that a certain amount of copper sulphate is permanently retained in the pores, giving an additional and decided preservative effect.

The Telephone in Railway Service

AT a recent meeting of officials and employees of the Union Pacific Railroad at Omaha, L. H. Korty, superintendent of telegraph, spoke of the important part played by the telephone in railway service.

The telephone is becoming a most valuable aid in the operation of trains in large yards and terminals, and quick work is necessary because of the constantly increasing volume of business.

It is most necessary that the train dispatcher, telegraph office, yardmaster, car inspector, roundhouse, towers, and switch shanties should be supplied liberally with telephones. By a liberal use of the telephone between these, much time often may be saved for freight conductors and whole train crews and also in expediting the starting of trains.

Telephones are soon to be constructed in connection with the automatic block system now being installed, as they will place the dispatcher in close touch with the non-telegraph stations. Portable telephones may also be placed on trains for use on these wires in emergency cases. On some other sections of the road it is contemplated to introduce the composite system, by means of which one wire may be used simultaneously for telegraphing and telephoning. Trains will be equipped with portable composite telephone apparatus, enabling conductors to reach the dispatcher or nearest telegraph office.

Several complete circuits are already in use on the Union Pacific road whereby, in each case, several stations on a district are thus connected with the dispatcher and much valuable use derived therefrom by the dispatchers and trainmen conferring with each other. Where the use of the composite is impracticable, the most economical arrangement is to string a single iron wire between a siding and nearest telegraph office and connect with telephones. This places trains at sidings within reach of the dispatcher.

Experiments with telephones on trains are in progress on the Union Pacific road which, it is hoped, may result in devising apparatus that will make it possible for the engineer and conductor to successfully carry on conversation and compare their understanding of orders.

A wrecking car on each division is supplied with two portable telephones, and a reel carrying one-quarter mile of insulated wire for use at wrecks, washouts, etc., which are used to place the temporary telegraph office in communication with the repair work, the covered wire being stretched along the ground. The arrangement keeps the division office promptly advised as to the progress of repairs, etc.

The movement of trains by telephonic orders in certain localities under proper safeguards is possible, and is already being done on some roads. On the Union Pacific between Council Bluffs and Gilmore in conjunction with the block signal system the movement of trains is very greatly facilitated by use of telephones by the dispatcher in one of the towers. Official and private cars, while standing on side-tracks at important terminals, may be quickly connected with private branch exchanges, or local and long-distance lines, thus giving the occupants of such cars telephonic service as at their offices or homes. Such an arrangement is in vogue at the Omaha union station.

Long-distance telephone lines between division and district terminals would afford invaluable service to operating and traffic departments in giving orders and exchanging information which now overburden the telegraph wires. Mr. Korty said he looked forward to the time, in the not distant future, when the telephone service of the Union Pacific will be coextensive with that of the tlegraph; with long-distance telephone circuits along the main lines capable of satisfactory use between the extreme limits of the road, not as a rival of the telegraph, but rather as an auxiliary thereto, and as a direct and quick means for personal conversations between officials, agents and others. Each system has its particular advantage over the other, the telegraph being the best where a record is required.

While a storage system of lighter weight for use in electric vehicles would undoubtedly be welcomed by both the manufacturer and purchaser, there is little likelihood, according to "The Automobile," of a radical change in the near future in battery construction, due to the recently reported discoveries of large quantities of cobalt in the western section of North Carolina. These cobalt beds have been known to exist for a number of years, and as the application of that mineral for use in storage battery construction is yet in an early experimental stage, a considerable period of time must elapse before the perfected product could be put on the market should the experiments prove successful. Intending buyers of electric vehicles are safe in purchasing the standard products.

A gift of $100,000 has been made to the University of California by Clarence H. Mackay for a professorship of electrical engineering.

FIG. I.—TWO ELECTRICALLY OPERATED COAL TIPS IN HAMBURG HARBOUR, GERMANY

Electrically Operated Coal Tips

IN the May number of THE ELECTRICAL AGE, it will be remembered, were described a number of electrically operated cranes built by the Vereinigte Maschinenfabrik Augsburg and Maschinenbau Gesellschaft, Ltd., of Nürnberg. As of further interest electrically operated coal tips built by the same company are here described.

The two coal tips, shown in the illustrations, were recently supplied to the State of Hamburg for use in connection with the new Kuhwärder harbour in unloading coal directly from cars into barges and lighters. They are placed about 230 feet apart and close to the coal quay, on which are the tracks over which the coal cars are hauled.

The tilting device proper of each of the two coal tips is a combination of two separate tips, the outer one of which works automatically and is intended for use with low water levels, as in Fig. 2, while the other is electrically driven and is used for high water levels, as in Fig. 3. It may be mentioned that the water level in Hamburg harbour varies from 6½ to 20 feet.

The automatic tip, which is operated by the weight of the coal to be unloaded, is similar in design to the coal tips in use in the Ruhr harbours. The ramp, or inclined part, carrying on the water side a patented grip for catching the car to be unloaded, is common to both tips. With the automatic outer tip, the inner end of the ramp bears on two pins located on the girders which support the mechanically driven outer tip, while in the event of the latter being used, the ramp is coupled to these girders.

Below the ramp, a tooth-wheel segment, with its center coinciding with that of the bearing pins of the ramp, engages a pinion, the shaft of which is located on the frame of the outer tip. On this shaft is mounted a hand-operated band brake outside of the frame of the outer tilting device.

The car to be unloaded is run on the ramp, which is then in a horizontal position, the front axle is caught by hooks and the brake is then released. As, with a loaded car, the center of gravity lies now in front of the axis of rotation of the moving parts, the ramp is made to tilt. The inclined position of the ramp is maintained by the brake, since, when the car is empty, the center of gravity of the whole is back of the bearing pins. When the brake is released this causes the ramp to assume a horizontal position, as shown in Fig. 1.

By means of this tip, cars having a wheel base of 8 to 13 feet and of 10 to 20 tons capacity, are tilted automatically. For cars having longer wheel bases a hand winch can be resorted to to supplement the automatic action. The catching hooks above mentioned are free to move in the longitudinal axis of the ramp by means of hand cranks, so as to give a favourable tilting moment for each wheel distance. For this purpose an index is provided on the left side of the foundations.

For operating the electrical tilting device the outer tip, as above mentioned, is coupled to the inner one, so that the two box-shaped girders are rigidly connected to the ramp located between them. At the outer ends the girders are pivotted on the foundation, while at the inner ends they rest on wooden sleepers, with the iron construction connecting them below the ramp.

The whole tilting device is surmounted by an iron framework, on the platform of which is arranged the engine house. In the latter are the motor-driven winches for the operation of the inner tip, in addition to the necessary switching devices. From the two double drums of the tilting winch, wire ropes are

FIG. 2.—FOR LOW-WATER LEVELS, THE TIP IS OPERATED AUTOMATICALLY BY THE WEIGHT OF THE LOADED CAR

FIG. 3.—FOR HIGH-WATER LEVELS, THE TIP IS OPERATED BY ELECTRICITY

carried over the rollers located at the back ends of the tilting ramp and thence over the rollers of a tightening and compensating device. The drum shaft is operated by a 50-H. P. series-motor driving through gearing. At the back end of the tilting ramp, idlers have been arranged, which guide the ramp during its motion on the frame. The weight of the inner tip is compensated for by means of counter-weights, arranged on both sides and moving in pits behind the frame.

About 30 seconds are required to tilt the cars 45 degrees. To limit the motion in the two end positions, an automatic disengaging device is provided, and to stop the motor an electro-magnetic jaw brake is provided on the motor shaft.

Independently of the tilting winch there have been installed in the engine house winches for operating the chute. If the tilting device be not in use, the chute is raised into the upper position, as shown in Fig. 1, so as to be out of the way of the ships. The inner end of the chute is displaced by means of a 4½-H. P. series motor driving cable drums through a worm and gear. Another series motor of 7-H. P. operates the cable drums for hauling in the outer end of the chute.

The chute was so designed as to be able in case of necessity to hold the contents of one wagon. At the outer end, which is somewhat narrow, two adjustable folding doors have been fitted, and these can be used to regulate the speed of dumping. The length of the chute can also be changed by hand from 19½ feet to about 24½ feet.

The driver's stand to operate the chute and the electrically driven tip is in the engine house on the water side. Close to the driver's stand are arranged indices for the chute and the tips. In addition, there is in the engine house the switchboard for power and light distribution. The engine house, to which convenient winding stairs lead, is provided with double walls, consisting of pitch pine inside and teak wood outside. Current is supplied from the Kuhwärder power station at 440 volts. The electrical equipment was supplied by the Siemens-Schuckert Werke.

Each of these coal-tips will discharge about 15 coal cars of 10 to 20 tons' capacity per hour, in the case of electrical operation, and about 20 cars with automatic operation, though these figures can be increased.

A twenty-line automatic telephone system is to be installed on Andrew Carnegie's Scottish estate.

Radium and Cathode Rays

By RICHARD MEADE BACHE, Member of the American Philosophical Society

So much that is abstruse, and, on the other hand, so much of the daily newspaper order, has been written about radium, that what is given here will be of interest as describing the phenomena of its actions in a clear and simple way.—The Editor.

THE aim of this article is to give the reader a glimpse of the most recent one of the notable discoveries in science, one revolutionizing all previous conception of the constitution of the earth. As opposed to the earliest, and wholly erroneous conception, that earth, air, fire, and water are the only earthly elements, or uncompounded principles in matter, about seventy real ones are now recognized.

Atoms, forming molecules, or collections of atoms, of any substance, were regarded until recently as the smallest particles in existence, and also as indivisible. One might, it was thought, for it was done, break up molecules, but not atoms themselves. We were right and we were wrong. The atoms of which we were then thinking were the only smallest particles then known.

By the test of chemistry, the smallest and the lightest of them all is the atom of hydrogen. We had not, and could not possess, prior to the recent discovery, knowledge that anything smaller existed, for all our knowledge of minute particles of matter came through chemistry. Chemically, the atom of hydrogen necessarily still remains the smallest and the lightest of them all.

But we have now found, through the discovery referred to, that some particles exist which are called corpuscles, or little bodies, compared with which the atom of hydrogen is gigantic, sometimes at least a thousand times greater. More than that, it has been simultaneously discovered that matter, instead of being, as previously regarded, incapable of action without extraneous force, is, at least in some of its forms, endowed with intense activity.

The priceless value of observing familiar phenomena that daily appear around us, and of collecting and collating their various manifestations, as possibly leading to conclusions regarding their cause, was never better exemplified than in the case of observation of the conduct of electrical discharges in glass vessels in which atmospheric pressure had been reduced by the air pump. This experiment, which was at first generally regarded as only capable of affording the gratification of a curious and pretty spectacle, is, nevertheless, what led, step by step, to the recognition of artificially produced corpuscles of great motive power, and to that of their correspondence with others emitted by lately discovered matter.

Everyone who has ever seen the spark of a static electrical machine knows that it passes in a bright line from pole to pole. When, however, instead of passing under ordinary atmospheric pressure, it is delivered in a glass receptacle in which there has been great reduction of the pressure through the instrumentality of the air pump, there is no longer a well-defined bright line discernible from pole to pole, but in its stead a glow is produced. If, in the glass receptacle, air at a certain degree of reduced pressure be present, it will be observed that the contents will look blue near the negative pole, and on the opposite point of the glass receptacle, as on a target, will appear green light. The negative pole is, in fact, firing its negatively charged corpuscles at the place forming the green target.

The terms anode and cathode, or positive and negative, to designate the opposite poles of an electric machine, whether static or galvanic, are often misleading to the general reader, giving the idea that electricity passes exclusively from the anode to the cathode, from the positive to the negative pole, but not in the opposite direction, from the cathode to the anode, from the negative to the positive pole. The fact is, however, that each pole gives out a characteristic force representing the effluence which passes into and through the opposite pole.

The characteristic effluence differs in effects physically, visually, and therapeutically. Therapeutically, or as affecting disease, the case is beyond the intention of this article; visually, everyone can satisfy himself of the fact; physically, it only needs to cite one circumstance, that the gust of negative, or cathode, corpuscles, being deflected in one direction by a magnet, the gust of anode corpuscles can be deflected by the magnet only in the opposite one.

The cathode gust, which we see as rays, can be experimentally shown, by means of an electrometer, to carry a charge of negative electricity to its target of green light, and by the same means it can be shown that the anode gust conveys a charge of positive electricity to the cathode. The first rays, those from the cathode, demonstrably composed of corpuscles, bombard the side of the glass opposite the cathode, where the green light is. They have been found by calculation to move with approximately a third of the speed of light, the velocity of which is between 180,000 and 190,000 miles per second. The rays from the anode, corresponding to those from the cathode (the latter being also called canal rays, because they were discovered by passing them through an opening in the cathode), have less velocity than the others, or at least less penetration. They bend in opposite directions when subjected to the same magnetic influence.

The Roentgen rays, so-called from their discoverer, a distinguished German physicist, who named them the X-rays, are not pure and simple cathode rays, but are an emanation from them, produced by the impact of cathode rays upon a hard surface, and are, therefore, in a word, rays of secondary formation. Soon after the discovery of the X-rays, a man wrote to a newspaper, inquiring if the rays are not sometimes called "wrenching-rays," because they twist. A person once questioned the author about the "cross-rays," interpreting X to mean rays that cross one another.

Simultaneously with these experiments and discoveries, were proceeding researches dealing with elements capable of spontaneous action of a high order, resulting finally in the wonderful discovery, by husband and wife, Monsieur and Madame Curie, in the isolation of radium. This, beyond any other kind of matter known, is an element that has been found to possess an activity and a duration of function beyond anything heretofore suspected to exist. It is known that a piece of it would lose only about half its power in 1500 years, and would still have 1 per cent. of it left after a lapse of 10,000 years. Its rays are threefold in energy and character. Each has been designated by scientists by a Greek letter, but they will be here called by the corresponding English letters, *a*, *b*, and *g*. Each of them has its individual velocity, or at least penetrative power, which with them does not seem altogether to depend upon mass as well as upon velocity.

These rays chemically affect a photographic plate, the influence on it of the *b* rays (which are the same as the cathode rays of the electrical machine) being more conspicuous than the influence of the others. The *a* rays, which are charged with positive electricity, can be stopped by thin films of metal, yet they are known to have the greatest energy of discharge of the three kinds. Nevertheless, the *g* rays have a greater penetrative power than the others, having been known to pass through nearly 3 inches of lead.

We have the authority of a statement in one of the volumes of the "Physical Science Series," of Cambridge, England, that the mass of the positively charged corpuscle of radium is a thousand times greater than the mass of the atom of hydrogen, and that the mass of the negatively charged corpuscle of radium is a thousand times less than that of the atom of hydrogen. Therefore, the mass of the *a* corpuscle of radium is two thousand times as great as that of the *b* corpuscle. The velocity of the *a* corpuscle has been calculated to be only about a tenth that of light. This may account, with its greater mass, for its penetrative power being less than that of the other corpuscles.

As in the case of the two artificially generated rays from the anode and the cathode of an electrical machine, two of the three rays of radium, the *a* ray and the *b* ray, can be deflected from their course, but only in opposite directions, under magnetic influence. The ability to sever them, in both cases, under the influence of magnetism, was what led to the discovery that the *b* rays of radium are of the same kind as the cathode rays from the electrical machine.

There is, however, this marked difference between them, that whereas the velocity of the corpuscles from the cathode of the electrical machine has been approximately determined at a third of the speed of light, the corpuscles from the *b* rays of radium have been calculated to be much more than half the speed of light. A description of the apparatus and the equations, by which these and other determinations of velocity have been made, could be given, but they would be inappropriate in an account like this.

The most apparently extraordinary action of the gusts of corpuscles from radium is that of the *g* rays. They, unlike the two other kinds of radium rays discussed, are not deflected by the magnet, and are, as already mentioned, capable of passing through nearly 3 inches of lead; but they are also, in their usual association with some cathode rays, chiefly instrumental, through their corpuscular bombardment of neighbouring objects, in producing upon some substances, especially upon diamonds, the most vivid and beautiful effect of liquid, light-blue illumination. Under their gust of corpuscles, the real diamond glows with a purity that reveals its true water, and sets at naught spurious stones of white translucency.

It does not seem surprising that the sun, prime source of all phenomena in our planetary system, chemically composite in constitution, should both produce and excite to various phenomena; but that radium, isolated from other substances, and therefore necessarily assumed to be elementary, should give out three kinds of rays, different in force and other characteristics, seems at the first blush extraordinary. And yet, what do we call extraordinary, or simply strange in nature? Only that which we do not understand; and how little of it we do understand!

The author has gone far enough to show what a boundless field lies here for further investigation and discovery. We may all confess with Shakespeare, in view of these late wonders, that there are many things in heaven and earth not dreamed of in our philosophy. More, in all probability, lie invitingly beyond than present themselves as possible even now to the most enlightened understanding and the keenest vision into the past.

The trials of a single-phase traction system conducted for some time past by the Maschinenfabrik Oerlikon, of Zürich, Switzerland, on the Seebach-Wettingen line, are said to be progressing favourably. A great deal of experimental work was found necessary in order to reduce the interference which the first plant caused to the working of the local and trunk telephone lines which run parallel to the railway. At first the line was worked with alternating current at 50 cycles, when it was found that the induction trouble in the telephone circuits was sufficient to render the telephone service almost impossible. The telephone circuits had copper returns. In order to reduce the trouble, the Oerlikon Company experimented with lower frequencies for the supply to the railway locomotives. They found that with 15 cycles there was absolutely no influence on the working of the telephones, and it is now being proved that 20 cycles are also serviceable.

A bust of Volta was recently presented to the British Institution of Electrical Engineers by the Associazione Elettrotecnia Italiana.

Fabrics for Electric Heating

A PROCESS for producing woven materials suitable for electric heating purposes is described in a recent issue of "L'Electricité." A special flexible resistance wire, which can be drawn of any required section, is used, and is uniformly interwoven with the ordinary material of the cloth. The resulting material, whether composed of hemp, cotton, wool or silk, and whether heavy or light in texture, is not noticeably different from the same material without the electric heating wires. All strain is taken by the textile material, so that the conducting part can be safely made of extremely small section, and offers a large heat radiating surface.

The large number of circuits employed enables the voltage between neighbouring conductors to be kept down from one-half to one volt, and so prevents all danger from short circuits. Current is led to the various groups of conductors in parallel by means of special leading-in wires running along the opposite edges of the cloth.

Carpets, bed-covers, foot-warmers, and the like, are made up on this principle, and offer a safe and effective method of internal heating. It is only necessary to connect the leading-in wires to the electric supply through a suitable fuse and switch in order to raise the surface of the material to a uniform moderate temperature, which is usually 30 degrees to 35 degrees C. above the atmosphere in the case of carpets, and 20 degrees to 25 degrees C. in the case of foot-warmers and the like.

Amongst the many applications to which this system of heating lends itself are the medical treatment of rheumatism and other cases requiring the application of a gentle heat locally; the filtering of syrupy liquids, which have to be treated at a definite temperature, the drying of paper by passing it over endless bands of the heated cloth, and the construction of compact foot-warmers for tramway and railway carriages.

According to a bulletin recently issued by the New York Telephone Company and the New York & New Jersey Telephone Company, showing the increase in telephones in New York City during the month of June just past, the total net gain in telephones for the month is given as 3591. This is against a gain of 2217 telephones during June of 1905, an increase for June, 1906, over the same month of last year of 62 per cent.

Progressive Business Methods in Denver

WHEN the more than 50,000 members of the Order of Elks met in Denver, Col., this month, one of the attractive electrical displays in their honour was an arch, illustrated on this page, erected by the Denver Gas & Electric Company. Across the top of the arch is the word "Welcome," which, with other parts of the arch, is outlined with incandescent lamps, 1600 in all. It affords an excellent example of the value of electric lighting for display advertising or spectacular effects. The arch weighs 70 tons, is 60 feet high, and the driveway is 34 feet wide. It is constructed of iron, plated with bronze and with an antique finish.

The building of the arch was an outgrowth of a spirited campaign begun some years ago by the Denver Gas & Electric Company to increase the sale of current for lighting and other purposes. This campaign was successful from the start, and in a short time hardly a dark corner could be found in any portion of the business district.

This increased demand for advertising purposes created a demand for better public lighting, until now Denver claims a place among the best lighted cities in the country. The ambition to make Denver known as "The City of Lights" became a public one, and the arch is one result of this spirit.

A fund, started with the object of impressing the visitors with the up-to-date methods of lighting in Denver, soon totalled $22,000, contributed by business firms and a large number of citizens. With this fund the arch was erected, to express the hospitality of Denver to every visitor to the city. It stands at the Union Depot, and was dedicated on July 4, before 10,000 people. In accepting it as a gift to the city, the Mayor emphasized the value of lights as a means of welcoming visitors.

As a further evidence of its progressive spirit, the Denver Gas & Electric Company has established a "school of practice," in which will be taught all the pinciples which have made for the success of the company, and in which new problems in the gas and electric business will be worked out. The school is the idea of Henry L. Doherty, president of the company. The present pupils are twenty students from various colleges and universities of the country, namely, Cornell, Michigan, Wisconsin, Massachusetts Institute of Technology, and Dartmouth. Each student has graduated in some course in the engineering department of his alma mater.

Mr. Doherty has mapped out a two-years' course for his charges, during which they will acquire a full knowledge of the conduct of each department of the gas and electric business. Although all the students have, thus far, had a technical training only, they will not confine their efforts to this side altogether. They will be given thorough instruction in those methods which have been found to be best in securing large sales of gas and electricity.

There is every reason to expect that Mr. Doherty's idea will prove invaluable to the companies in which he is interested, as the school will always keep him supplied with capable men, able to conduct his plants successfully.

Denver has figured prominently in the electrical world in the past few years. Heretofore it was by reason of the fact that few cities of her size had a more extensive public and commercial lighting display. At the

AN ELECTRIC ARCH IN COURSE OF ERECTION BY THE DENVER GAS & ELECTRIC COMPANY FOR THE "ELKS" CONVENTION AT DENVER

A NIGHT VIEW OF THE ARCH

present time there is a wave of popularity in favour of electricity for all purposes. For instance, the Shirley and the Albany may be classed as electric hotels, as they are equipped with nearly every electrical appliance necessary for the convenience of their guests. The Shirley, which is conducted in connection with the Shirley Annex, recently gave up its own plant, as it was found to be inadequate for all purposes of its general service, and is now purchasing its current from the Denver Gas & Electric Company.

All the pleasure and comfort that electricity may afford are provided by the Shirley Hotel. The sign which greets the guests on entering the hotel is a model of its type. It is most effective and exceedingly tasteful. The lighting arrangement in the lobby shows careful study, and there is hardly room for improvement, so far as pleasing effects go.

Those rooms which are occupied by permanent guests have every electric appliance necessary for comfort and convenience. The electric chafing dish is very popular, as there are many private parties. The massage vibrator is another appliance which is used to a great extent in these rooms, and one may find in nearly every room little electric heaters for curling irons. In fact, everywhere about the hotel there is evidence of the great conveniences which electricity, applied to diverse uses, provides.

The example of the Albany and the Shirley will be followed by the other Denver hotels, as the electric hotel increases the effectiveness of the service of any hotel.

The Explosion Hazard of Electrical Appliances in Collieries

CERTAIN precautions for reducing the danger resulting from the ignition of firedamp by sparking of electrical appliances in mines have been given out by the Gelsenkirchen testing station, in Germany.

Experiments extending over a period of three years indicate that the hermetical casing, wire gauze protectors, and oil-bath casings are best. Each of these, however, is best suited for certain particular conditions.

The hermetical casing is not suitable for appliances that are likely to get hot while in use; in such a case ventilation would be necessary. This form of device is also heavy, having to be built very strong, but has the advantage of being able to withstand considerable external shock.

The wire gauze casings are easily ventilated, and are both cheap and light, but are not very strong. The gauze should be of the normal dimensions used in safety lamps, viz., 1-75-inch wire, and 940 meshes to the square inch. Bronze or galvanized steel wire is the best material, and should be as carefully cleaned and kept free from defects as the ordinary safety lamp gauze. No soldering is permissible on the gauze, and the latter must be tightly screwed into rigid frames and also be protected from external injury by perforated sheet metal, fastened over it.

The oil-bath casing affords the best protection of all, since it entirely prevents access of firedamp to the parts where ignition could arise. The casing should always be filled with sufficient oil to cover all sparking parts. The point showing the necessary depth of oil should be marked on the casing, and the actual level of the oil at any time should be visible without opening the casing. Where a transmission of current occurs beneath the surface of the oil, the contacts should be so constituted that no extensive decomposition, or gasification, of the oil will occur beneath the surface. The shape of the casing should preclude any exposure of the sparking parts by violent motion of the oil.

Other protective measures, such as locking devices, and the like, should be used in addition to the different styles of casing mentioned.

The best form of casing to use for motors of low capacity, such as those used for rock-drills and coal-cutters, is the hermetical casing. For motors of larger size, used for driving fans, air compressors, pumps, winches, etc., the wire gauze is preferable. For switches and safety plugs, the hermetical and oil-bath casings are best, because no ventilation is needed; in fact, all starting resistances and transformers may generally be immersed in oil.

Limits for the Use of Niagara Power

IN accordance with the law passed by Congress at its recent session, providing that the Secretary of War might issue permits for water to be taken from Niagara River to the extent of 15,600 cubic feet per second, Secretary Taft has granted temporary permits as follows:—

Niagara Falls Power Company, 8000 cubic feet per second; Niagara Power Company, 4000 cubic feet per second; Lockport Hydraulic Power Company, 500 cubic feet per second from the Erie Canal and 333 cubic feet from the lower level of the canal at Lockport.

In the case of the Albion Power Company, it is the opinion of the Secretary that the use of water from the river by the company does not fall within the law, and for the present he has withheld his decision concerning that company. He has also decided to postpone consideration of the application of the Niagara Falls Trust Company, as executor of the estate of Henry E. Woodruff, deceased, giving as his reason that water is not being used by the company.

Secretary Taft's decision permits the Niagara, Lockport & Ontario Power Company to import into the United States from Canada the equivalent of 25,000 horse-power from the Ontario Power Company of Canada, and the Niagara Power Company is also authorized to import from the Canadian Niagara Power Company not to exceed 25,000 horse-power daily.

These two permits are the only ones granted for the importation of the electricity generated in Canada. The Secretary says that it will be necessary to make a thorough investigation before granting permits to the two companies. He has designated Capt. Charles W. Kutz, of the Corps of Engineers, to make a full report on the Canadian power, and when it is submitted the report will be laid before the International Waterways Commission.

According to "The Automobile," an extremely novel and interesting surface-increasing device for air-cooled gas-engine cylinders has been made as follows:—Copper wire of square section was wound over a form as if to make a long helical spring, except that the form was triangular instead of round, the triangle having a short base and two long sides. Inside the spring-like coil thus made was run a flat copper ribbon, and the whole was wound around the cylinder, the copper ribbon pressing the short base of the triangular coil closely against the casting. Then the cylinder was placed in an electro-plating path and the coils united to the casting by a heavy coating of copper.

A trackless trolley line is in operation in Italy between Spezia and Portovere, a distance of about two and one-quarter miles.

The Lubrication of Bearings

As the successful operation of machinery depends in large part upon the ability of the bearings to run continuously without undue friction and wear, says A. M. Mattice, in a recent issue of "The Electric Journal," the proportions and details of the bearings demand the utmost care on the part of the designer. In a great many cases bearings give trouble, although the surface velocity and pressure per unit area are well within safe limits, and although proper lubricant is applied in ample quantity, the troubles being caused by the lack of attention to small, but essential, details.

One of the commonest causes of trouble in two-part bearings is side binding. This occurs principally in vertical engines and in other machinery where the principal load on the bearing is that due to the dead weight of the rotating part. The bearing boxes are too often bored and scraped to a good fit all around without being eased off to prevent wedging action near the parting of the boxes. This not only causes a tremendous pressure on the bearings at these points, but prevents the oil from getting in between the shaft and the bearings.

A bearing is always much better if eased off so that it will be well clear of the shaft for at least 20 degrees of arc on each side of the centre line, and even 30 degrees is not excessive. Many designers, especially those who have not had practical experience in the operation of machinery, seem to dislike to lose any part of the bearing area by easing off the sides of the boxes, but area at these points is more detrimental than efficient, and bearings which are originally made with all around contact can frequently be improved by the use of hammer and chisel.

Let the oil have a fair chance to get in its work. The edges of the bearing boxes are frequently left sharp, thus scraping off the oil instead of assisting it to enter. If the box is eased off to form a channel for the oil, meeting the shaft approximately on a tangent, oil will be drawn in instead of being scraped off.

In the matter of oil grooves also, designers frequently seem loth to sacrifice bearing area, apparently losing sight of the fact that no area, no matter how great, can be sufficient unless properly lubricated. Oil grooves should be large, arranged so as to keep the oil well distributed, and should have the edges well rounded off to facilitate the entrance of oil between bearing and journal. The simple removal of the sharp edge of the groove is not sufficient.

Too many designers, moreover, seem to look upon the matter of oil grooves as of too little importance to be worthy of their consideration, but rather something to be left to the shop to take care of, or to be neglected entirely. The result frequently is an oil grooving which does more harm than good, letting the oil to certain parts of the bearing and leaving other parts dry.

In the days of slow-moving machinery it sufficed to use tallow or pieces of pork-fat, placed in openings in the bearing caps and resting directly upon the shaft. As machinery grew heavier and speeds increased, the necessity for some more efficient means of lubrication made itself felt. It was known that oil was a good lubricant, but there was the difficulty of applying it in some automatic manner without waste.

Finally, some genius hit upon what in its day was considered the acme of perfection in the matter of lubrication, feeding oil by means of wick siphons. A number of holes in the bearing cap connected with the oil reservoir above the level of the oil. In these holes were placed wicks, dipping in the oil. The rate of feed was regulated by the number of wicks or the number of strands in each wick.

It was not so very long ago, either, that these primitive methods were the only ones in vogue. When the writer first went to sea, about 33 years ago, the only methods of lubrication were wicks for the engines and tallow for the line shafts. The introduction, some years later, of adjustable drop-feed oil cups was a marked improvement, followed later by the addition of "sight feeds," so that the attendant could see what was going on, instead of increasing or decreasing the feed according as the bearings felt too hot or otherwise.

From time to time various systems of improved lubrication have appeared, such as ring oiling, chain oiling, felt pads, packed waste, compression and spring grease cups, etc. But with the exception of the "splasher" system, which is very efficiently used in a number of types of enclosed engines, the old type of drop-by-drop lubrication, feeding the oil in homeopathic doses, is the one most generally used with engines, although it is about the least efficient and most expensive method of all.

The smaller the amount of oil fed to the bearings, the more it costs. This at first seems paradoxical, but it is true, for the reason that if just enough oil is fed to the bearings to permit of motion without damage, the oil becomes "worn out" by excessive friction. If, on the other hand, an excess of oil is supplied, a less quantity is actually worn out, while the excess can be recovered and used over again.

This old system of drop-by-drop lubrication is not only wasteful, but it leads to danger of cutting the bearings by reducing the oil supply to a dangerous minimum. It is not altogether the fault of engine builders that this form of lubrication is the one most generally used by them, but rather because purchasers will not stand the slight additional first cost of a better method.

Ring oiling and kindred systems are very efficient for a large class of bearings, but unfortunately are not well adapted to engine work, especially in large sizes, although some designers have done some very good work along this line. Ring oiling, however, is admirably adapted to many forms of electrical apparatus, and is probably used to a greater extent in that class of machinery than in any other.

Grease and similar lubricants have their limitations, but are ideal lubricants for many purposes, and in engine work can be used to good advantage on the smaller parts of valve gear, and even on eccentrics.

Supplying oil under pressure is a necessity with step bearings which carry very heavy weights, and has been applied with success to horizontal bearings where the work is extremely heavy; but this class of lubrication may be considered as adaptable only to special cases where it is an absolute necessity, to be avoided if possible.

The central gravity system of lubrication, which has come into extensive use in engine installations within the past few years, has resulted in a marked saving in cost of lubrication and the elimination of bearing troubles, and the details of such systems are well worth the serious attention of engineers. The writer refers to the systems which, while varying in details, comprise essentially an overhead supply tank, pipes leading to all bearings with valves for regulating the supply, arrangements for catching the overflow oil, settling tanks, filters and pumps for returning the oil to the supply tank, the whole system being automatic, and resulting in a continuous circulation of oil.

Although this system is at present used principally in large installations, it has been used with success in smaller plants, and the writer believes that engineers would be justified in using it in installations of single engines of large, or even moderate size. Its success is not only due to the saving of labour, as in large installations, but by supplying an excess of oil to the bearings the oil does not become "worn out," as in the drop-by-drop system, thus resulting in a reduction of oil bills.

A further extension of the principle of continuous circulation of oil obtains in the flooded system of lubrication which has come into use in connection with steam turbines. In fact, this system was introduced by Parsons before the central gravity system for reciprocating engines came into vogue. This system consists in supplying to the bearings as much oil as will flow through them; the oil carrying away the heat of the bearings and being cooled in a tubular cooler before going back to the bearings again.

The oil is not forced into the bearings under pressure, but simply supplied at a head of from a few inches to several feet,—just enough to allow it to flow freely to the bearings. As the oil is nowhere exposed to the outside air, circulating only in a closed system, it collects no dirt and does not need to be filtered, but is used over and over again continuously, the entire oil supply circulating through the bearings every few minutes.

By means of this flooded system speeds and pressures are used which would otherwise be impossible, and, what is of still greater interest to the owner, the oil consumption is reduced to a minimum. As instances of this may be cited the cases of two installations of 400-KW. steam turbines of the Parsons type running at 3600 revolutions per minute, one of which used only 50 gallons of oil in six months and the other one 55 gallons. At another plant one turbine of 400-KW. and another of 750-KW. used only three barrels of oil in sixteen months. In another case two 1000-KW. turbines used one-half gallon of oil per turbine per week.

Some months ago the writer crossed the Atlantic on the turbine steamer "Virginian," and upon inquiring about the consumption of oil, found that no oil had been added to the supply during four successive round trips, and the original supply had not appreciably diminished. The service tank contained a little less than 150 U. S. gallons, and this was being circulated through the bearings at the rate of between 40 and 50 gallons per minute, the whole supply being circulated in less than four minutes.

In the case just cited the oil referred to was that for lubricating the bearings of the three turbines. The line shafting was lubricated by the old drop-by-drop method, and used up a considerable quantity of oil, whereas the more exacting needs of the turbines themselves were met by the waste of practically no oil at all.

As another example, the turbine steamer "Queen Alexandria," which in the summer season makes daily trips on the Clyde, used less than one barrel of oil during a season of between four and five months.

Users of engines and other machinery would do well to take a lesson from the results of steam turbine lubrication, which has demonstrated beyond a doubt that the supply of oil in large excess of that actually required to prevent bearings cutting is, in the long run, the most economical, and far in advance of the old drop-by-drop method.

Another matter upon which a few words may not be amiss is that of the temperature of bearings. There seems to be a wide misapprehension as to what is a safe temperature. Much of the idea about safe temperatures is an inheritance from the time when lubricating oils were all of animal or vegetable origin, and is not applicable to the high-test mineral oils of to-day.

Some time ago the writer happened to get into a controversy as to proper bearing temperatures, the immediate cause of which was an engine whose main bearings ran at a temperature of about 135 degrees F., while the owner claimed that a temperature of over 100 degrees was unsafe, and produced "expert" testimony to that effect.

Knowing from experience that this view was not correct, but requiring testimony to the contrary, the writer proceeded to have examinations made of the temperature of bearings of a large number of engines of various makes. The result of this investigation showed more large engines running with bearings at temperatures over than under 135 degrees. Many bearings were running at over 150 degrees, some considerably higher, and in one case a continuous temperature of 180 degrees was found, and in all of these cases the bearings were giving no trouble.

Long Distance Transmission in Switzerland

After an investigation of various schemes for affording an extension of the local supply of light and power, the Zurich municipal authorities, says "The Electrical Review," of London, have decided to carry out a project for the utilization of the water power of the Albula River, which is to be dammed and the water led to a turbine-generator station on one bank of the stream. It is estimated that the expenditure on the works will amount to $2,140,000, and the scheme require from three to four years for its execution.

Although the distance between the place of production and the center of application is 86 miles, a decision has not yet been arrived at as to the use of the alternating or the continuous-current system for transmission. The alternating-current scheme proposes the employment of four circuits having three wires in each and a pressure of 46,000 volts from the generating station. The direct-current project contemplates a pressure of 79,000 volts, which will be reduced by one-half by the use of a double circuit.

Both systems provide for the erection of watch-houses at distances of about 14 miles, which will be in telephonic and telegraphic communication with the generating station and the Zurich transforming station, and each 14-mile section will be regularly examined by the attendants permanently engaged in connection with the watch-houses, which will be combined with dwellings.

It is reported that it has thus far been found impossible to use electric locomotives for hauling trains through the Simplon tunnel. It is stated that when the metal surfaces of the locomotives, chilled by the outside temperature, entered the warm, moist atmosphere of the tunnel, the amount of condensation upon them was so great as to affect the insulation of the conductors and cause short circuits. The motors are now being altered to obviate this difficulty.

Combined municipal water supply and electric power generation is said to be contemplated by the Eureka Lake & Water Company, owning extensive properties in Northern California. At one point in a pipe line for a proposed water supply for San Francisco, sufficient head could be obtained to generate 15,000 H. P.

Electrical and Mechanical Progress

Tantalum Incandescent Lamps

TANTALUM lamps now being produced in this country at the General Electric Company's lamp works at Harrison, N. J., are shown in the annexed illustration. They are offered to the electrical trade as giving the highest efficiency of any form of commercial incandescent lamp available to-day.

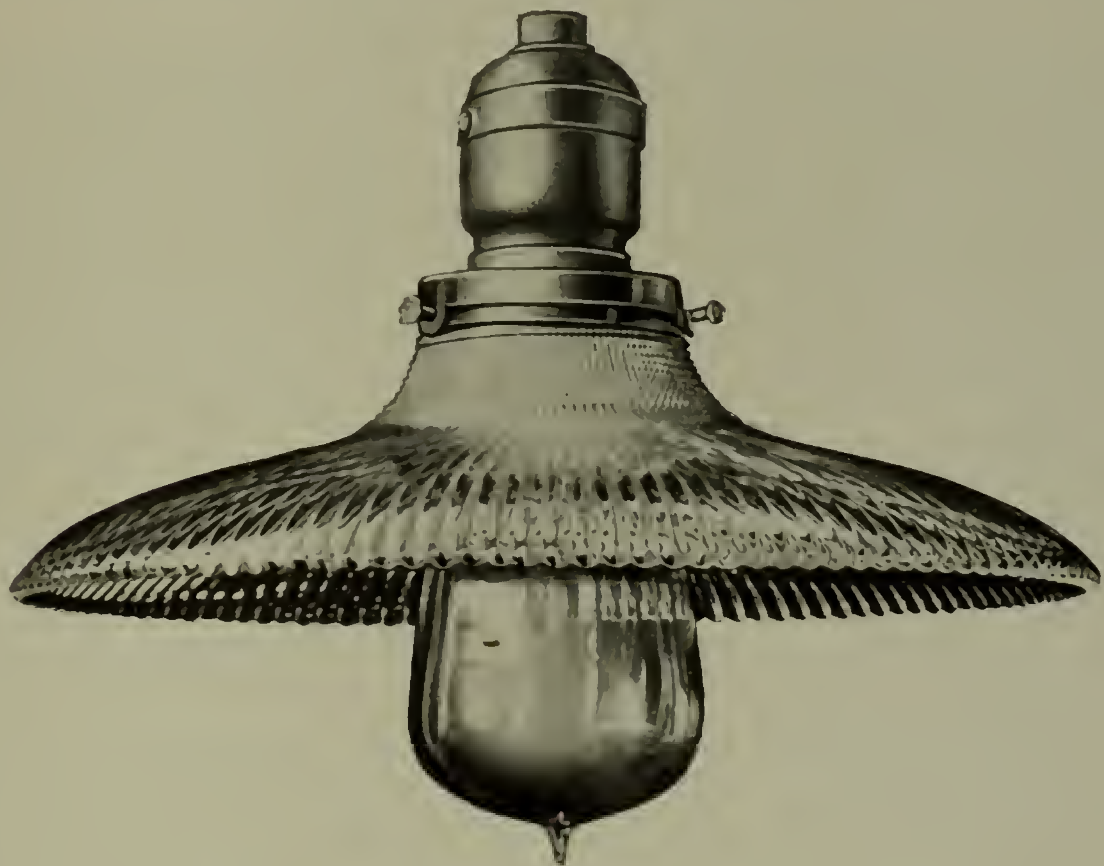
The saving in the cost of the lighting to the customer puts a large premium upon higher efficiency lamps and the latest production of invention and research is really notable in results obtained. The General Electric tantalum lamp, it is claimed, gives an actual efficiency of two watts per candle, based on the mean horizontal English Parliamentary Standard, with an average useful life on direct-current circuits of 700 hours or more.

The construction and general appearance of the new lamp are clearly shown in the illustrations. When used with the special "Holophane" pagoda reflectors provided with the lamps, the downward lighting efficiency, it is claimed, is increased to one watt per candle or better. Two forms of reflectors are provided, the distributing form, which gives a characteristic meridian distribution, and the concentrating form which gives a more centralized distribution beneath the lamp.

The lamp is at present supplied by the General Electric Company in but one size, having a consumption of 44 watts and giving a mean horizontal rating at 22 candle-power. It is made for voltages of 100 to 130 volts and fitted only with standard Edison base. It is not recommended for use on alternating-current circuits.

This lamp will enable central stations to reduce the cost of lighting to the customer and therefore meet and resist competition, secure additional desirable business and increase its net earnings. While the first cost of the tantalum lamp is somewhat higher than that of the ordinary carbon filament lamp, this additional cost is saved several times over by the consumer buying light at average meter rates given by electric lighting companies.

The average life of these lamps is about 750 hours, and their value, as shown by the saving they secure in consumers' cost of lighting at various rates per kilowatt-hour, is given in the following table:—



A 22-CANDLE-POWER, 44-WATT TANTALUM LAMP WITH DISTRIBUTING FORM OF REFLECTOR, MADE BY THE GENERAL ELECTRIC COMPANY, HARRISON, N. J.

SAVING IN COST OF CURRENT AT VARIOUS RATES AT 22 C. P.—44 WATT G. E. TANTALUM LAMPS

Rate per Kw. hour cents	Over present 3.5 w. p. c. 22 c. p. lamp	Over present 3.1 w. p. c. 25 c. p. lamp
10	$2.47	$1.80
11	2.83	1.98
12	2.97	2.15
13	3.24	2.33
14	3.47	2.51
15	3.72	2.69

It is expected that the new lamp will be supplied to lighting customers on direct-current circuits on a liberal policy as to charges, either on a renewal or on a purchase basis. The lamp possesses several very attractive features which should appeal both to the central station man and to his customer. The advertising value of this new lamp as a novelty represents an asset to the lighting company first introducing it to the public in its section. The brilliancy and quality of light of the tantalum lamp is unsurpassed, and, it is predicted, will render it most attractive to the consuming public.

On an equal pro-rated useful life basis with present 16 candle-power, 3.1 watts per candle lamps, central stations now supplying free renewals of 16 candle-power, 3.1 watts per candle lamps could afford to supply tantalum lamps at a low figure without adding to their present lamp renewal costs.

Central stations which are now furnishing free renewals of 3.5 watts per candle lamps could similarly supply the tantalum lamp at a little higher figure without increasing their renewal costs. In any case, the consumer, as shown by the foregoing table, would save several times the value of the charges of the tantalum lamp.

Central stations will have opportunity to exploit the tantalum lamp with their customers and give them every opportunity to profit by their use.

The advertising value of this new lamp as a novelty will no doubt be taken the fullest advantage of to the end of pleasing the progressive and most desirable customers and exemplifying a progressive policy on the part of the central station.

GENERAL ELECTRIC TANTALUM LAMP WITH CONCENTRATING FORM OF REFLECTOR

American-Ball Engines and Generators

THE American Engine Company, of Bound Brook, N. J., the manufacturers of the American-Ball engines (both simple and duplex compound) and of electric generators and motors, report among their recent sales the following:—Two 80-H. P. duplex compound engines, to the De Lamar Copper Refining Company, of Perth Amboy, N. J.; three duplex compound engines, to the E. I. du Pont Company, of Wilmington, Del, being their seventh order for this type; three duplex compound engines, to a San Francisco firm; two 200-KW. engine-type generators, to be water-wheel-driven, to the W. D. Boyce Paper Mills Company, of Marseilles, Ill.

The American-Ball simple engines are somewhat similar in design and construction to others of their type, distinct advantages and economies, however, being claimed for them.

The advantages and economies of compounding, while very great in the case of the slow-speed Corliss-type engines, are claimed to be even greater in proportion in the high-speed, single-valve engine.

There are many advantages in the duplex compound type not found in either the tandem or cross-compound types. The chief among them is its compactness. The American-Ball duplex compound engine occupies no more floor space than a simple engine of less power. The high and low-pressure cylinders are cast together, one directly below the other. One cross-head carries both piston rods, while a single continuous valve of an improved design controls the admission and exhaust in both cylinders. The admission and exhaust are simultaneous in both cylinders, thus securing an even distribution of the work between the two pistons.

The inertia governor is one of the chief characteristics of the American-Ball engines. It is said to maintain a speed regulation within one-tenth of one per cent. from no load to full load suddenly applied.

A continuous oiling system is provided which does not depend upon the splash principle, but is positive in its action.

The generators built by the company conform to the most approved principles of modern practice. Special attention has been devoted to the matter of armature ventilation. This is one of the most important questions which confront the dynamo designer and constructor. Wm. E. Kent, M. E., says, "Resistance varies with temperature,—for every degree Fahrenheit the resistance increases 0.2222 degrees." Armature heating, is, therefore, always accompanied by an unavoidable increase in resistance, loss of efficiency, and loss of generator capacity.

Heating is kept as low as possible in the American-Ball generators by a single large air duct, dividing the armature, transversely, into halves. This acts like a centrifugal blower, drawing a great volume of fresh air through the armature and giving a thorough ventilation to the machine.

Another item in the maintenance of low armature temperature is the formation of the coils. These being of solid bar copper, wound with cotton and thoroughly insulated, allow a greater cross-section of copper (and thus larger conductors) to be put in the slots than if the more bulky tape-wound wire coils be used. In this manner a greater current-carrying capacity is obtained with less resistance, and therefore less heating under load.

The company is specializing in the construction of complete generating sets. There are many times when the purchaser prefers to deal with one manufacturer who builds both parts to run together and assumes the entire responsibility for the proper performance of the unit.

The generators have the same mechanical excellence that has distinguished the many thousand engines designed and built by Frank H. Ball, general manager and engineer-in-chief of the American Engine Company.

An Interesting Example of Motor Drive

AN excellent opportunity for comparison of the advantages of motor drive over belt drive is afforded by the two illustrations on this page, showing the brass department of the Bausch, Lomb, Saegmuller Company, of Rochester, N. Y. The contrast between the individual drive and belt drive is very marked, and the increased light and cleanliness in places such as this, where very fine work is done, will make a large return on the investment.

The motor equipment was manufactured and installed by the Rochester Electric Motor Company, of Rochester, N. Y., who are making a specialty of the smaller sizes of motors and generators.

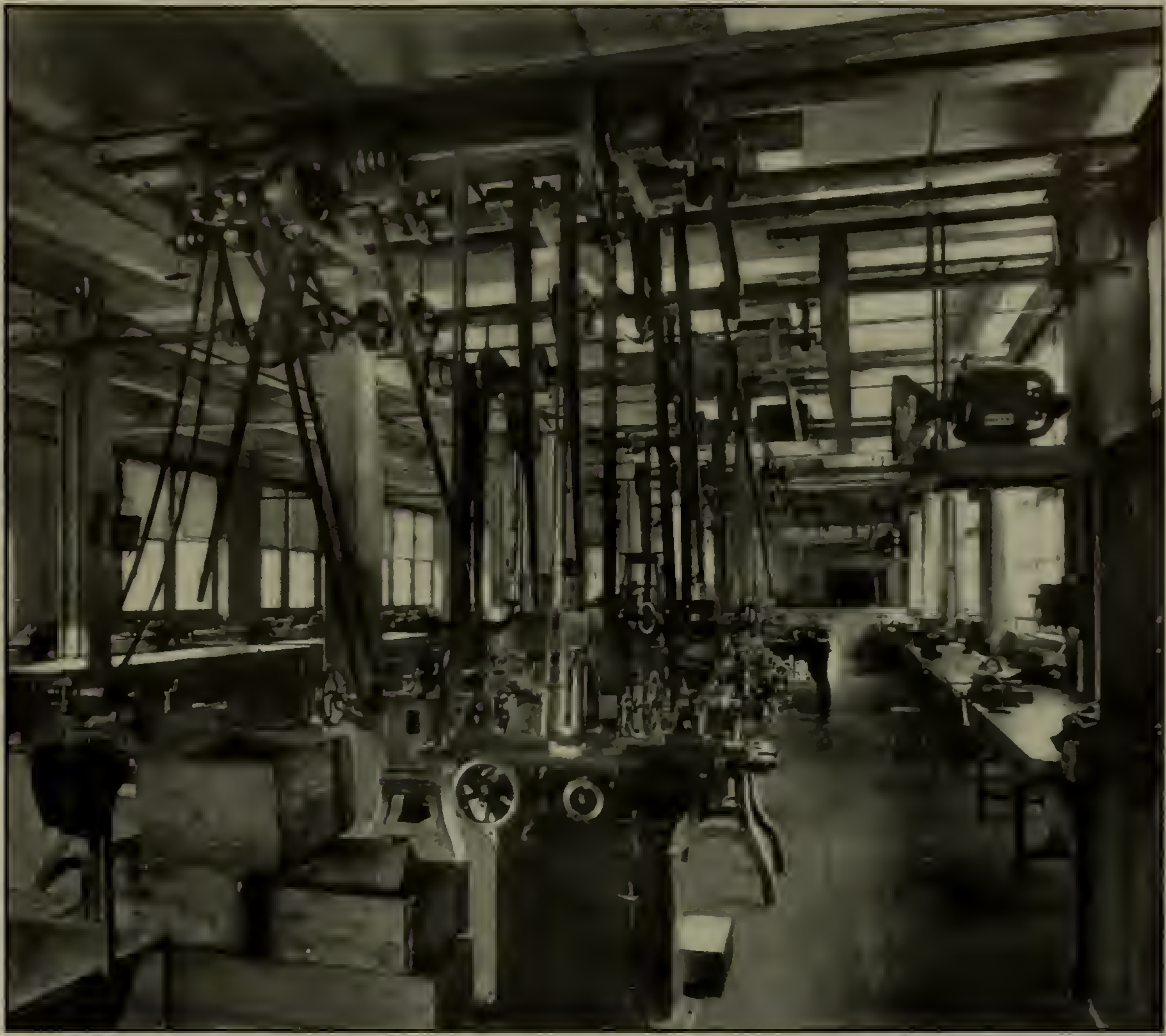
The motors are run on a single voltage of 220, direct current, a speed variation of 2 to 1 being obtained by varying the strength of the shunt field. On the motor shaft is keyed a two-step cone, the drive being by means of a short rawhide belt.

The motor is supported on a cast-iron bracket bolted to the machine bed and supported at the outer end by an iron pipe leg, which also serves as a runway for the feed wires. The motor circuit is independent of the lighting circuit.

Full reverse controllers, manufactured by the Globe Electric Company, of Amsterdam, N. Y., are provided, with two armature contacts, for starting only, and ten running points.

Electrical Generating Equipment for the Indiana Steel Company

THE remarkable extent to which the use of electricity for power purposes has been developed in the innumerable industrial plants of the country, will be nowhere better exemplified than in the proposed electrical equipment of the new Gary (Indiana) Steel Plant, plans for the building of which were recently announced by the United States Steel Corporation.



TWO VIEWS OF THE BRASS DEPARTMENT OF THE BAUSH, LOMB, SAEGMULLER COMPANY, OF ROCHESTER, N. Y., SHOWING THE INCREASED LIGHT AND CLEANLINESS, DUE TO THE MACHINES BEING DRIVEN BY MOTORS BUILT BY THE ROCHESTER ELECTRIC MOTOR COMPANY

When completed, it is estimated that the plant will handle substantially 5,000,000 tons of ore a year, and produce annually approximately 2,500,000 tons of steel. There will be sixteen blast furnaces of 450 tons daily capacity each, and eighty-four 60-ton basic open-hearth furnaces. The necessary electrical generating equipment capable of handling such an output is to have an initial capacity of 18,000 KW., and will be so designed that extensions may be added indefinitely at one or both ends.

The initial equipment will have a capacity of 18,000 KW., 14,000 KW. being in 2000-KW., 25-cycle, 2300-volt units, and 4000 KW., 250-volt, direct-current units. These generators are now on order from the Allis-Chalmers Company, of Milwaukee, and will be direct coupled to nine Allis-Chalmers horizontal twin-tandem gas engines.

The power house building for the present is to be approximately 700 feet long with a span in the main building of 88 feet. An 18-foot extension under the same roof through the entire length of the structure, has been planned in order to provide the necessary room for high-tension switches. The power house will be located immediately adjacent to the blast-furnace blowing-engine houses, and between the blast furnaces and the open-hearth furnaces most advantageously placed for fuel supply and for securing a minimum length of transmission lines to the various departments using electric power.

The Allis-Chalmers alternators and direct-current generators will be built at the company's electrical works in Cincinnati.

"Nokorode" Soldering Paste

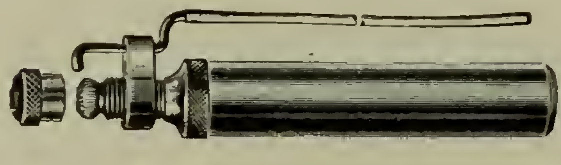
THE merit of "Nokorode," a soldering paste, manufactured by M. W. Dunton Company, of Providence, R. I., lies, it is

A CAN OF "NOKORODE" SOLDERING PASTE MANUFACTURED BY M. W. DUNTON & COMPANY, PROVIDENCE, R. I.

claimed, in its non-corrosive qualities, in the fact that it can be used in soldering all metals except aluminum, which does not need a flux so much as a solder with a low melting point. It is also claimed to be economical, as very little is required for work to be soldered.

In compounding it, nothing but the purest products are used, and care is taken to mix them in proportions to make the flux homogeneous.

To the bottom of an old galvanized iron tank used on a gas stove



THE POCKET BLOW TORCH OFFERED BY M. W. DUNTON & COMPANY, FOR FIFTY TIN COVERS OF THEIR CANS OF "NOKORODE" SOLDERING PASTE

for years, without cleaning or preparing the surface in any way, a brass ring was soldered. The attempt was made to separate the two by force, with the result that the galvanized surface was pulled from the iron without breaking the joint.

Other tests were made as follows:—On a greasy Norway iron armature a small place was filed smooth and bright, after which a piece of copper wire was soldered. When cool, the copper wire broke under force, but the joint held good.

With an ordinary flat-head wood screw, the head of which was not very new or bright,—in fact, it was somewhat rusty,—the entire head and slot were covered with solder, by the use of "Nokorode."

One of the most conservative telephone companies would not pass on "Nokorode" until they had made six months' exhaustive test to determine its non-corrosive qualities, as well as its soldering properties. Since adopting it they have used it exclusively, ordering one hundred one-pound boxes at a time.

In introducing "Nokorode," it was found that many buyers were not interested, for the reason that they purchased so little soldering paste that they paid very little personal attention to the matter, and left it principally to the workman and left its selection to him.

In many cases the workman was not familiar with the various grades, and decided on the most expensive or the most advertised as sure to be the best.

In order to attract the attention of the workmen, M. W. Dunton & Co. conceived the idea of offering their "Little Beauty" pocket blow-torch, illustrated herewith, for the return of fifty tin covers from two-ounce decorated cans, feeling sure that the merits of "Nokorode" would make its continued use assured.

With this object in mind, one hundred alcohol pocket blow-torches, $5\frac{3}{4}$ inches high by $\frac{7}{8}$ inch diameter, were obtained. The size of the flame is adjustable, the torch is thoroughly nickel plated on brass, and is very neat and attractive.

For some reason, the original offer, which expired July 1, 1906, did not attract the desired attention, although it was advertised quite extensively. It was, therefore, decided to renew the offer until July 1, 1907.

A New Insulator Pin

IN the description of the transmission line and third-rail system of the Long Island Railroad in the July number, attention was called to the new type of iron insulator pin employed. This pin, which is a radical departure from previous practice in pin design, is the invention of W. N. Smith, of Westinghouse,

INSULATOR PIN DESIGNED BY W. N. SMITH FOR THE TRANSMISSION LINES OF THE LONG ISLAND RAILROAD

Church, Kerr & Co., of New York. Mr. Smith has applied for a patent on the device. The design has been further improved, and arrangements are now being made for manufacturing and placing it on the market, under the name of "The Smith-Grip Insulator Pin."

It combines several important advantages, as follows:—It does away with the necessity of boring holes in the cross-arms, thereby conserving the whole strength of the arm and lengthening its life; the metal composing it is distributed in the most effective manner possible, as its cross-section is greatest next to the arm, where the greatest resistance to bending is required; and finally, the shrinkage of the arm can more effectively be taken care of by the U-bolt and strap than by any of the other forms of pin fastenings in common use, as there is no tendency to distort the bolt, and, consequently, there is no possibility of the pin standing crooked upon the arm after the shrinkage has been taken up. Furthermore, it is practicably indestructible, and instead of being one of the weakest factors in line construction, this pin is expected to be the strongest.

More than 8000 of the pins, as originally designed and shown in the accompanying illustration, were used in the transmission line construction of the Long Island Railroad, carrying 250,000 c. m. cables in spans averaging 150 feet in length, and no failures have yet been reported after over a year of service. A dozen or more standard sizes of the improved design are being worked up to fit several sizes of cross-arms and pole tops, and to carry insulators of varying sizes up to the highest voltages in practical use. The pins will be made of either cast or malleable iron to suit the purchaser's conditions, and will, it is believed, fill a long-felt want for a pin which combines, at a reasonable cost, the maximum of strength and durability both in itself and in the cross-arm to which it is fastened.

While it is designed particularly for use with wooden cross-arms, it can readily be adapted to steel cross-arms, and to such special fixtures as are often necessary in heavy transmission line construction. On account of its superior mechanical design, it will also without doubt find a place in heavy catenary trolley construction, which is now being actively developed for the electrification of railways by the single-phase system.

After the arrangements for placing the Smith-grip pin upon the market have been perfected, a more detailed announcement will be made, that will be of interest to engineers and others interested in following the march of improvement in the mechanical construction of power transmission lines.

A New Mercury-Arc Rectifier Outfit

A NEW and improved form of mercury-arc rectifier outfit recently placed on the market by the General Electric Company, of Schenectady, N. Y., is shown in the annexed illustrations. While the old form of panel has been very satisfactory during the past two years for charging storage batteries, and other uses, the new type has several improvements, tending to make the complete outfit as simple as possible.

FIG. 1.—NEW MERCURY-ARC RECTIFIER OUTFIT MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

As will be seen from Fig. 1, the panel is of simple and neat design, equipped only with such switches and instruments as are absolutely necessary for the satisfactory operation of the rectifier. At the top is a double-pole, automatic, overload circuit breaker, connected in the direct-current line, which not only protects the rectifier tube against any sudden overload, but also the storage battery or other device to which the rectifier is furnishing direct current.

The instruments comprise an ammeter of a size corresponding to the maximum current obtainable from the rectifier with which it is mounted, and a voltmeter varying in capacity according to the maximum voltage of the rectifier. The only other switches on the panel are a load switch of special design, on the right, an alternating-current line switch, on the left, and the reactance switch below.

It will be noted from Fig. 2 that the rectifier tube is mounted on the back of the panel where it is less liable to breakage from accidental causes, as persons striking against it or the like. The tube is mounted in a holder, which is connected to a small handle in front of the board.

FIG. 2.—REAR VIEW OF THE GENERAL ELECTRIC RECTIFIER OUTFIT IN FIG. 1

By turning this handle slightly from right to left, the tube will be rocked and the small starting arc formed.

At the bottom and on the back of the panel is a small reactance coil. This is connected in series with the alternating-current line and has taps brought off from it which are connected to the buttons on the regulating switch, as shown in Fig. 1. This reactance is used for obtaining a fine adjustment and is of such design that it serves admirably for the purpose.

The compensating reactance, complete with a regulating dial switch, is mounted on the floor just below the panel. The function of this part of the outfit is to obtain a neutral point for the rectifier which will furnish the negative pole of the direct current. On this compensating reactance, taps are brought out to the dial switch above mentioned, by means of which a rough adjustment of current may be obtained before starting the tube. When the same machine is being charged each day this rough adjustment may be fixed once for all, and only the reactance coil on the panel need be used.

The method of starting the new panel is as follows:—Set the dial switch on the compensating reactance to the approximately correct point (readily found after the tube has been started the first two or three times), and set the regulating reactance on the panel at the lowest point. Close the circuit breaker and the alternating-current line switch shown at the left of the panel in Fig. 1. Hold the starting switch on the right in the starting position with one hand and turn the small starting handle with the other end and the tube will start after one or two shakes.

The starting switch is arranged with a spring so that it is normally closed in the load position. On releasing the starting handle, the starting switch will therefore return automatically to the load position, and the rectifier will be sending direct current to the load. This load current may be regulated after starting by means of the reactance switch on the panel, which gives a wide range of adjustment without any appreciable sacrifice in efficiency.

To anyone familiar with the old type of panel this method of starting will be seen to be extremely simple. Moreover, the complete apparatus, with the exception of the reactance beneath the panel, is arranged to be shipped as a unit so that the outfit may be operated just as soon as the pipe frame can be screwed to its supports and the connections made.

Consolidation of Electric Railways

A NUMBER of electric railway lines in Ohio were merged recently in the incorporation of the Indiana, Columbus & Eastern Traction Company, with a capitalization of $12,000,000. The interests promoting the merger are those long identified as the Widener-Elkins syndicate, and the intention is to take over all the traction lines in Ohio which have been held by the Ohio syndicate, of which W. Kesley Schoepf, of Cincinnati, is chairman, and J. H. McGowan, of Indianapolis, chairman of the Indiana syndicate, is vice-president. The United Gas Improvement Company, of Philadelphia, represented by Randall Morgan, is behind the two syndicates.

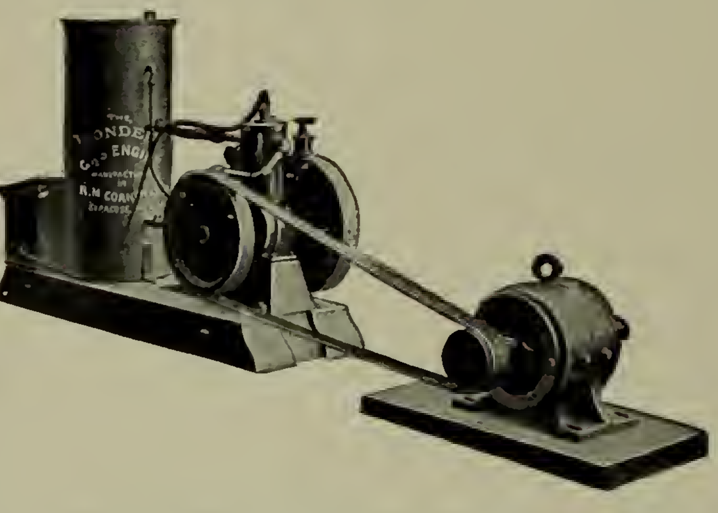
The consolidated company will operate over 500 miles of interurban lines,—a larger mileage than is now controlled by any other single corporation. It will cover all of Central and Western Ohio, and by connection with the lines of the syndicate in Indiana will be enabled to operate through cars from Zanesville to Terre Haute, Ind.—a distance of over 300 miles. The principal cities which it will connect are: Cincinnati, Toledo, Cleveland, Columbus, Zanesville, Dayton, and Newark in Ohio, and Indianapolis and Muncie in Indiana.

The company will solicit both high-speed passenger and freight traffic. Sites have been secured in Dayton and Columbus for large passenger and freight union stations. The station to be built in Columbus will cost in the neighbourhood of $1,000,000.

Small Electric Lighting Units

THE construction and operation of small electrical generating plants have become so simplified in the last few years that they are now made for practical use in lighting houses with a capacity as low as fifteen lamps. It will be seen that such a plant will serve a great many purposes, and make a very welcome addition to isolated farmhouses and similar establishments which may be out of reach of gas or electricity.

The R. M. Cornwell Company, of Syracuse, N. Y., realized early the demand for such an outfit, and commenced experiments with the view of arriving at a design which would be simple, compact, and easy to operate, and, at the same time, capable of being sold at a low price. These small outfits are built in several sizes, one with an engine of 1½ H. P., capable of supplying current for fifteen lights. With a 3-H. P. engine,



A SMALL GAS-ENGINE LIGHTING UNIT BUILT BY THE R. M. CORNWELL COMPANY, OF SYRACUSE, N. Y.

thirty lights of 16 candle-power can be used. Of course, by making use of a lamp of lower candle-power more lights are available.

The outfit is shipped, as shown in the accompanying illustration, connected with gasoline and water tanks, and also all electrical connections made, so that the machine is ready to operate as soon as the tanks have been filled with gasoline and water. Where it is desired, these outfits are supplied with everything necessary for complete installation, including voltmeter, ammeter, wire, lamp cord, receptacles, and rosettes. Such an outfit is very desirable for an up-to-date farmhouse, cottage, shop, or, in fact, any place where an efficient and uniform light is desired. It is said to be possible, with one of these outfits, to light a building at a rate cheaper than can be done by a lighting company.

These goods have been regarded with favour by foreign buyers, and the company referred to have worked up quite a considerable foreign trade.

The cost of this outfit is very low, and the expense of operating is also inconsiderable. It is claimed that the 3-H. P. engine can be operated at full capacity for ten hours at a cost of thirty cents.

Gas-Engine Blowing Plant for the Indiana Steel Company

WHAT will eventually develop into perhaps the largest gas power plant in the world has its inception in an important contract recently placed with the Westinghouse Machine Company, of East Pittsburg, Pa., for eight large gas-driven blowing engines to be installed in the steel plant at Gary, Ind. As it is the expressed intention of the United States Steel Corporation, which controls the Indiana Steel Company, to make this the foremost American steel center, the significance of simultaneous development of gas power is obvious.

The machines comprised in this initial order will be uniform in size and capacity. Each gas engine will have a rated capacity on blast furnace gas of nearly 3000 H. P., corresponding to a rating of 400 H. P. on natural gas. The unit will be arranged in twin-tandem fashion, each side consisting of two double-acting gas cylinders and one blowing cylinder in the opposed or "vis-a-vis" arrangement. Power cylinders are 42 inches, and the air cylinders 68 inches in diameter, with a common stroke of 54 inches, the unit running at a maximum speed of 75 revolutions per minute. The capacity of air delivery at this speed will be 33,000 cubic feet of free air per minute at 18 pounds pressure, with a maximum pressure delivery of 30 pounds per square inch.

This type of engine will not only be used for blowing purposes, but also for electrical generation. For the latter purpose, the revolutions per minute will be 84. In all sizes a resemblance to the horizontal tandem heavy-duty steam engine design is strong. The general design conforms quite closely to that of similar machinery ordered by the United States Steel Corporation for the Carnegie Steel Company's plant at Bessemer, near Pittsburg. It also follows closely, but upon a larger scale, the design of a number of smaller units already in operation in various parts of the country for power work; notably those at the plants of the Warren & Jamestown Street Railway Company, of Warren, Pa., the Standard Steel Car Company, of Butler, Pa., the Iola Portland Cement Company, Iola, Kan., the Carnegie Technical Schools, of Pittsburg, and others. Some of these smaller plants are operating on natural gas, but with the exception of slightly different proportioning of air and gas passages and cylinder diameter, the general construction of the natural gas engine is practically identical with that intended for leaner gases, such as producer and blast-furnace gases.

For several months a 350-H. P. engine of this type has been in regular operation on blast-furnace gas at the Edgar Thompson Works, Pittsburg, generating electricity for motor-driven foundry machinery. The engine was installed largely for experimental purposes and has given such excellent operating results that the success of the larger machines may be regarded as an assured fact. At the time of going to press this engine was completing a 30-day continuous load and duty test, operating 24 hours per day and seven days per week during the period.

Personal

Lewis Buckley Stillwell, who is one of the electrical commission of the Erie Railroad, sailed for Europe shortly after completing with Bion J. Arnold the report on the electrification of the Erie Railroad Company's lines. The trip will be for rest and recreation, especially for Mrs. Stillwell, whose health has not been of the best for some time.

Among the recent passengers leaving New York for Liverpool on the Cunard steamer "Caronia," was President W. H. Whiteside, of the Allis-Chalmers Company, of Milwaukee. He was accompanied by his wife and daughter, and will devote several weeks to a recreation trip abroad. Mr. Whiteside and his family will visit various points of interest in England, Germany, Switzerland and France, spending most of their time on the Continent.

M. B. Roper, formerly chief engineer for the Cananea Consolidated Copper Company, of Cananea, Mex., was recently engaged by the Power & Mining Machinery Company, of Milwaukee, Wis., as mining engineer to represent them at their New York sales office.

W. A. Lieblein was recently appointed manager of the Salt Lake City branch of the Power & Mining Machinery Company, of Milwaukee, Wis., with offices at Room 215, Commercial Club Building. Mr. Lieblein was for a number of years manager of one of the large Cripple Creek mining properties, and during the past few years represented the Rand Drill Company as manager of their Salt Lake City office. He has an unusually wide acquaintance throughout the Western mining country, and brings to the Power & Mining Machinery Company his practical selling experience of many years' standing.

James E. Denton, who for the last twenty-five years has been one of the faculty at Stevens Institute of Technology, in recent years occupying the chair of mechanical engineering, received the honorary degree of doctor of engineering at the recent thirty-first annual commencement of the Institute. Professor Denton has for a long time been prominent in professional circles, and is to-day one of the best-known engineers in the United States. His wide consulting engineering practice has kept him closely in touch with the practical and commercial aspects of engineering, and has helped to equip him exceptionally well for the post of engineering professor. He is a member of the American Society of Mechanical Engineers and of the Engineers' Club, of New York.

S. O. Ochs, who was formerly associated with the Stanley Instrument Company, of Great Barrington, Mass., is now representing the Fort Wayne Electric Works, of Fort Wayne, Ind., in New England territory, with headquarters at Boston. He is well known to the electrical fraternity throughout the New England States and also in New York.

It is announced that the degree of doctor of engineering has been conferred upon George Westinghouse by the Technical University of Berlin.

William Ransom Cooper, associated with James Swinburne, in London, has been appointed editor of the "Electrician," of London, in place of F. C. Raphael, who retired on June 30.

Frederick C. R. Spence has severed his connection with the Stanley Instrument Company, of Great Barrington, Mass., and is now with the Fort Wayne Electric Works, of Fort Wayne, Ind. He is acting in the capacity of a special representative in that city for the sale of meters, in which line of business the company has a large and increasing trade.

James H. Hessin was recently appointed superintendent of the Pontiac (Ill.) Light & Water Company, and also general manager of the Bloomington, Pontiac & Joliet Electric Railway Company, succeeding Fred L. Lucas.

John I. Beggs, president of the Milwaukee Electric Railway & Light Company, was recently presented with a bronze tablet as a mark of appreciation of the manner in which the affairs of the National Electric Company, of Milwaukee, were managed by him from April, 1905, to May, 1906. The company was brought out of financial embarrassment and reorganized under the name of the National Brake & Electric Company.

The officers whose names are inscribed on the tablet are:—J. H. Denton, general superintendent; R. P. Tell, secretary and treasurer; S. I. Wailes, general sales manager; W. L. Waters, chief engineer.

Dr. A. E. Kennelly, professor of electrical engineering at Harvard University, and well known as a writer on electrical engineering topics, was recently given the degree of Master of Arts by Harvard. Dr. Kennelly is one of the past presidents of the American Institute of Electrical Engineers.

George I. Rockwood has just been appointed to the professorship of steam engineering at the Worcester Polytechnic Institute. Mr. Rockwood is a graduate of the Worcester Institute,—a member of the class of 1888,—and is very well known in professional circles as one of the leading authorities on the subject of steam engineering. The Institute is to be congratulated upon having added him to its faculty.

C. J. H. Woodbury, of the American Telephone & Telegraph Company, recently received the degree of Doctor of Science from Union College.

The honorary degree of Doctor of Science was recently conferred on E. W. Rice, Jr., technical director of the General Electric Company, by Union College, at Schenectady, N. Y.

Dr. Schuyler Skaats Wheeler, president of the Crocker-Wheeler Company, of Ampere, N. J., and Prof. Francis B. Crocker, of the Columbia University, electrical engineering department, recently sailed for England to enjoy the hospitality of the British Institution of Electrical Engineers.

E. B. Raymond, general superintendent of the General Electric Company, of Schenectady, N. Y., underwent a severe operation recently, from which he is now convalescent, so that he has been able to go to Cape Cod for his vacation.

W. C. MacDowell, formerly connected with the mining department of the New York office of the Power & Mining Machinery Company, Milwaukee, Wis., was recently appointed manager of the El Paso, Tex., office of that company. His territory will comprise all of Mexico, New Mexico, and parts of Texas and Arizona. He has had many years' practical mining experience, and is well known to the mining fraternity in almost every mining district in this country and Mexico. He has been connected with the Power & Mining Machinery Company ever since its purchase of the old Holthoff Machinery Company in 1903. For nine years previous to this time he represented the American Smelting & Refining Company in various capacities.

Walter A. Pearson, formerly electrical engineer for the New York City Railway Company, has been appointed chief engineer for the Electrical Development Company, of Ontario, and for the Toronto-Niagara Power Company. J. W. Putnam, superintendent of lines and feeders in New York, will take charge of the transmission lines, under Mr. Pearson.

George H. Rowe has opened an office as consulting engineer at 1211 Fisher Building, Chicago. Mr. Rowe is well known as a designer of alternating-current apparatus, having been for some time connected with the Western Electric Company. He was for a number of years an instructor in various universities, and has contributed to some extent to the technical press. He will make a specialty of design of apparatus and transmission lines. He has had considerable experience in the latter branch while on the Pacific Coast.

Alson C. Ralph, of Boston, Mass., who has been with the Thomson-Houston and General Electric Companies almost continuously since January, 1891, as erecting engineer and expert electrician, has severed his connection with the General Electric Company, and accepted a position with Stone & Webster, of Boston, as superintendent in charge of construction and development work. He is now in El Paso, Tex., superintending the work of installing new apparatus at the El Paso power plant.

Clarence A. Ross, who has for the last ten years been identified with the Westinghouse Electric & Manufacturing Company, has resigned his position in order to take up the duties of vice-president of the Engineering, Construction & Securities Company, of Chicago. Mr. Ross carries into his new position experience in central-station construction and management, having built and managed the Ardmore (I. T.) Electric Company, the Holton (Kan.) Electric Company, and the Eldorado Springs (Mo.) Electric Company, owner and manager of the plants at Holton and Eldorado Springs.

Olaf Saugstad has opened an office at 13-21 Park Row, New York City, and will make a specialty of temperature and pressure regulation, especially in power plant work and in mechanical processes requiring close regulation. For the past three years he was connected with the Davis & Roesch Temperature Controlling Company and the H. & M. Automatic Regulator Company, as master mechanic and superintendent.

Dr. Lee De Forest, the wireless telegraph expert, recently survived a shock of 25,000 volts while he was sending a message from the wireless station at Ottawa, Canada, to Montreal. Dr. De Forest started to open the muffler, or soundproof box, at the Ottawa station. He grasped the iron handle on the door, and the full voltage of the transformer leaped from one of the lead wires to the handle and through his body to the cement floor. He was knocked unconscious, but quickly revived, and, aside from a partial paralysis, which soon passed away, he felt no serious effects. He is unable to explain why the shock was not fatal.

Obituary

William R. Fleming, general manager of the Harrisburg Foundry & Machine Works, of Harrisburg, Pa., and designer of the well-known "Fleming" engines built by them, died suddenly, in Washington, D. C., on July 6. He had been in ill health for several months. Mr. Fleming was born in Harrisburg in 1862. After spending eighteen months at the Harrisburg Foundry & Machine Works when a young man, he went to the works of the Pratt & Whitney Company, at Hartford, Conn., where he remained for four years. He afterward engaged in the selling end of the business at New York for the Harrisburg works, and in 1898 was made general manager of the company. He was a founder of the Engineers' Club of Central Pennsylvania, and a member of the American Society of Mechanical Engineers.

Charles C. Newton, president and treasurer of the Newton Machine Tool Works, Inc., of Philadelphia, Pa., died at Bremen, Germany, on June 13. His failing health was the cause of his trip abroad, but he was too ill to continue his travel after his arrival at Bremen. Mr. Newton was born at Cambridge, N. Y., in 1846. When nineteen years old he entered the Brooks Locomotive Works, at Dunkirk, N. Y., serving there as apprentice until 1875. In that year he became partner with J.

D. Cox in the manufacture of twist drills, reamers, cutters, and the like, and in 1876 the firm moved to Cleveland, Ohio. Mr. Newton sold his interest in the firm to Mr. Cox in 1880, and, locating in Philadelphia, laid the foundation for the present Newton Machine Tool Works. At first, the working force consisted only of himself and his assistant. The business grew, however, until it occupied an entire square, and up to July 14, 1897, Mr. Newton was the sole proprietor. Then articles of incorporation were taken out, and the firm became the Newton Machine Tool Works, Inc., with Mr. Newton as president and treasurer. He was a member of the American Society of Mechanical Engineers and of the Engineers' Club.

Louis Cassier

IN MEMORIAM

AMONG the victims of the appalling railway disaster on the London & South-Western Railway, on July 1, was Louis Cassier, the founder of "Cassier's Magazine," and president of The Electrical Age Company. Speeding from Plymouth to London, the fast night express, which carried mails and passengers from the American Line steamship "New York," left the rails near Salisbury. Twenty-three of the passengers were killed and many others injured, and the wreck generally was complete.

Mr. Cassier was on one of his frequent trips between New York and London, and, though usually accompanied by Mrs. Cassier on these journeys, was alone this time.

He was born at Boston in 1862, and immediately after leaving school began work in that city, in the advertising department of one of the daily newspapers. This he continued until, late in the eighties, he went to New York and there engaged in miscellaneous advertising work, principally in connection with the American edition of the "London Illustrated News."

Of restless disposition, with a vast amount of nervous energy seeking new outlets constantly, he soon felt the need of expansion in directions other than those which he had previously followed. Though not an engineer, engineering appealed to him as a field for publishing exploitation,—exploitation of a new kind with hitherto untried methods, and the result, after a comparatively brief period of planning, was the first number of the magazine bearing his name,—a magazine of illustrated engineering, intended to deal with steam, electricity, power. This was in November, 1891.

Disaster was freely predicted for the venture, but, with the buoyancy of spirit and courage of conviction which characterized him, the work of developing the new publication was pushed unremittingly. In the fall of 1894 a London edition of the magazine was started, and thus on both sides of the Atlantic the publication began to grow and spread to the gratifying proportions which it now has.

Not content with this measure of success, however, Mr. Cassier, late in 1903, purchased THE ELECTRICAL AGE, a periodical of many years' standing, neglected and indifferently managed until then, but of promising possibilities. The Cassier Magazine Company had meanwhile been formed, with The Electrical Age Company as a subsidiary organization, and with Mr. Cassier as president of both, and under this new ownership, THE ELECTRICAL AGE, reinvigorated, started out on a new career in 1904, with all signs pointing to as successful a future as that of "Cassier's Magazine." An English edition also of THE ELECTRICAL AGE, with offices in London, was projected when death overtook him.

Mr. Cassier was a cosmopolite,—at home on both sides of the Atlantic,—with hosts of friends and acquaintances. His personality was striking. To meet him was to remember him. Original, resourceful, enterprising, he combined in himself most of those qualities which stamp themselves upon men's memories.

He was an associate member of the American Society of Mechanical Engineers, and of the American Institute of Electrical Engineers, a member of the Iron and Steel Institute of Great Britain, and also of the Republican and Camera Clubs of the City of New York, the Manufacturers' Club of Philadelphia, and the Automobile Club of America. His home was at Trumbull, Conn., near Bridgeport, where he was buried.

Trade News

The W. R. Garton Company, of Chicago, have taken the general Western agency for the overhead railway materials manufactured by the Albert & J. M. Anderson Manufacturing Company, of Boston, Mass. "Ætna" insulation and Anderson products stand for everything that is good. "Ætna" insulation is one of the oldest insulations in existence, and many large properties are standardized on this material. The W. R. Garton Company have also taken the agency controlling a large portion of the output of the Main Hub & Manufacturing Company for the electrical insulator pin product. The latter company carry in stock at least one million pins at all times. These pins are made of winter cut black birch, one of the closest-grained, strongest-fibred and most durable woods grown on the American Continent. It is very long-lived, of high tensile strength, pleasing in appearance, and cheap in the long run. It has proved to be better than locust, in point of strength and durability. It is not readily attacked by rot or insects, and is one of the most serviceable lumbers to be found. Many vehicle manufacturers will use nothing else for hubs, because it has been found to be the most satisfactory. When used as insulator pins, it is the nearest approach of anything in wood to iron or metal. The W. R. Garton Company are convinced that they have an assembly of agencies representing the strongest possible manufactory of materials for electric railway construction and maintenance possible to group, such as the Lord Electric Company's products, the Thomas soldered bonds and Shaw lightning arresters, the Massachusetts Chemical Company's products, and those later additions already mentioned. It is very gratifying to the Garton Company to note that they have, thus far this year, closed up with various railroad companies in the neighbourhood of 175 miles of railway construction material, bonds, hangers, high-tension porcelain insulators and other like material for new propositions. The 250-mile point is expected to be reached before the close of the year.

The Denver office of the Allis-Chalmers Company has been removed to the McPhee Building, Seventeenth and Glenore Streets. The El Paso, Tex., office has been removed to the Guarantee Trust Building, Rooms 301-306.

The Newcomer-Manry Company, of Atlanta, Ga., have been appointed agents for the sale of line material and "Ætna" insulators, manufactured by the Albert & J. M. Anderson Manufacturing Company, of Boston. The former company recently acquired the agency for the Lord Electric Company's rail bonds, and as they already have the agency for the Schaper Construction Company's material, and a number of other well-known products, are well equipped for serving electric railways in their territory.

The Oneida Community, Ltd., of Oneida, N. Y., are now putting out a chain for the suspension of incandescent lamps for street work. This chain is of the same construction as their No. 1 Oneida galvanized chain commonly used for the suspension of arc lamps, and has the strength, durability and flexibility that is characteristic of No. 1 chain. This new size is termed No. 5 Oneida galvanized chain, and is made from the best open hearth steel, heavily galvanized at the Community's plant by the hot galvanizing process. This material will prove of interest to central station men for suspending incandescent lamps in the middle of the street. A sample length sufficient for the suspension of one lamp is furnished free of charge to any central station desiring to test the chain.

The De La Vergne Machine Company, of New York, reports the following recent sales of the well-known "Hornsby-Akroyd" crude and fuel oil engines:—The Fulton Bag & Cotton Mills, Atlanta, Ga., 50-H. P. engine to drive general machinery; F. P. Pfleghar & Son, New Haven, Conn., 125-H. P. engine direct-connected to generator; Wissahickon Electric Company, Fort Washington, Pa., 50-H. P. engine; Iola-Aurora Production Company, Iola, Kan., 20-H. P. engine for driving general machinery; Marconi Wireless Telegraph Company of America, New York City, 7-H. P. engine for furnishing current for a wireless telegraph station. An order was also received from the Standard Oil Company for two "Hornsby-Akroyd" oil engines of 25 H. P. each, which will be shipped to Chinkiang, China, and used for pumping purposes. The use of oil engines has increased enormously in the past few years, there being now over 14,000 oil engines of the "Hornsby-Akroyd" make in operation.

Westinghouse-Parsons Steam turbines, built by the Westinghouse Machine Company, of Pittsburg, Pa., are to be installed in the New York Navy Yard. The installation will comprise two 500-KW. units operating under 150 pounds steam pressure, 28-inch vacuum, and on superheated steam at 100 degrees Fahr. The power plant supplies three phase, 60-cycle alternating current at 2300 volts to machine shops, dry docks, and other general purposes about the yard, including lighting of buildings. Boilers will be of the Stirling water-tube type, with Foster internal superheaters. Worthington surface condensers will be used. This will make the second turbine plant that the Westinghouse Machine Company has installed for the Navy Department, the first one being at the Boston Navy Yard, where the turbines have been giving very good service. Two Westinghouse-Parsons turbines also will be installed in the Hoboken, N. J., terminal of the Delaware, Lackawanna & Western Railroad Company. They will drive 500-KW., three-phase, 60-cycle Westinghouse generators of the revolving-field, enclosed type. Babcock & Wilcox boilers and Worthington condensers will also be installed. Another steam turbine installation is that for the municipal lighting plant of Burlington, Vt. The turbines will be direct-connected to a three-phase, 2300-volt, 60-cycle generator.

The Abner Doble Company announces that it has relocated its offices at its former site, Fremont and Howard streets, San Francisco. The company is one of the first to resume operations in the burned district, and has taken contracts for a large amount of work in addition to the orders on hand previous to the fire. Work is progressing rapidly on the company's new shops and warehouses in the Potrero district at Seventh and Hubbell streets. Temporary pattern and forge shops are already in operation on the new site.

The Allis-Chalmers Company, of Milwaukee, Wis., have received an order from the Meriden Electric Light Company, of Meriden, Conn., for a 500-KW., two-phase, 60-cycle, 2300-volt Allis-Chalmers turbo generator unit to be installed at the power house in Meriden late in the Fall, for lighting and power purposes. In addition to the turbine and generator proper, the Allis-Chalmers Company will also furnish a structural steel foundation frame and a surface condenser with 2000 square feet of cooling surface, including centrifugal circulating pumps, air pumps, and the like. Units similar to this one are now on order for the city of Jacksonville, Fla.; the Western United Gas & Electric Company, of Aurora, Ill., and the Muncie Electric Light Company, of Muncie, Ind. Both turbine and alternator are the products of the Allis-Chalmers Company. The alternator will be built at the company's electrical works, Cincinnati, Ohio, and the turbine will be built in the West Allis, Milwaukee, works.

W. S. Barstow & Co., of New York, have been retained by the Derby Gas Company, of Derby, Conn., as engineers in making extensive additions to their electric power plant and distributing system. The present plant will be remodeled to conform with the new installation. When the plant is completed it will be one of the most modern of its kind, and will include some interesting departures from current practice. The firm have also been engaged as engineers for remodeling the plant of the Jamestown Worsted Mills, at Jamestown, N. Y. Plans will be drawn covering an extensive addition to the power plant, and the plant will be changed over to an electric motor drive throughout. Barstow & Co. recently completed a similar installation for the Hartford Carpet Corporation, at Thompsonville, Conn.

The Foos Gas Engine Company, of Springfield, Ohio, have just placed an order for $20,000 worth of machine tools, consisting of lathes, planers, boring mills, drill-presses, grinders, etc. Their business so far this year shows an increase of 50 per cent. over any previous year, and this extra equipment will enable them to make prompt delivery of all orders.

The Pacific Electric & Manufacturing Company, of Napa, Cal., has been organized to manufacture and sell high-tension switches for indoor and outdoor use, and all high-tension line appliances. Arrangements have been made with F. G. Baum, transmission engineer of the California Gas & Electric Corporation, for the right to manufacture the oil switches and outdoor switches designed by him.

Caxton Brown, until recently manager of the New York office of the Weston Electrical Instrument Company, of Waverly Park, Newark, N. J., is now secretary of the company and sales manager. Stanley Brown is now manager of the New York office. In connection with this office, a repair department has been installed, the duty of which is to take care of the repairs in the metropolitan district, and particularly to look after emergency calls. This new feature has been very warmly welcomed by the many users of Weston instruments in New York city, and has enabled the manufacturer to insure a higher degree of satisfaction to his customer than ever before. The company is very much pleased with the present instrument outlook, and is exceedingly busy preparing new models for measuring apparatus to meet the wider demands of modern electrical requirements.

Work has been begun on the building of a manufacturing plant for the American Telegraphone Company, at Wheeling, W. Va. The financing of this undertaking is in the hands of Charles K. Fankhauser & Co., and the Sterling Debenture corporation, of New York city. Since the first announcement of Poulsen's invention of the electro-magnetic "recording and speaking telephone," a corps of American experts have been working on the perfection of the instrument for commercial purposes. This has now been accomplished, and the company expects to be in a position to meet the demand for telegraphones which is at present far ahead of the supply.

The Salt Lake City district office of the Westinghouse Electric & Manufacturing Company was removed on July 2, to 212-214 Southwest Temple street, Salt Lake City, Utah. The Dallas district office was also removed on the same date to 418 Main street, Dallas, Tex.

The Philadelphia Rapid Transit Company has recently placed orders with the Westinghouse Machine Company, of Pittsburg, for a complete equipment of Roney mechanical stokers for their large subway power plant now building in Philadelphia. This plant was constructed for turbine machinery, and Westinghouse-Parsons turbines of 6000-KW. capacity will be installed. With the equipment of mechanical stokers and other labour-saving devices the plant will represent one of the most up-to-date modern power stations. The order covers stokers for the entire boiler plant of 32,700 H. P. Boilers are of the Parker water-tube type. The New York, New Haven & Hartford Railroad company recently adopted mechanical stokers for their large power plant at Cos-Cob, now building to serve the electrified section of their New York city terminal. The initial order comprising twelve stokers was recently placed. These stokers will serve twelve 520-H. P. Babcock & Wilcox water-tube boilers. The adoption of mechanical stokers at this plant thus follows the practice of all the large power generating plants in New York city and Brooklyn. The United Railway & Electric Company, of Baltimore, which has recently in operation one of the most modern and efficient boiler plants in this country, has had sufficient successful experience with mechanical stokers to justify recent extensions of their plant. The boiler house is double-decked, and three new batteries on the second tier are now being installed. This plant is the largest steam plant in Baltimore and passed through the Baltimore conflagration without damage, although the adjacent engine house was destroyed. A large order for mechanical stokers has also been received from the American Steel & Wire Company, of Pittsburg, covering equipments for nineteen boilers.

New Catalogues

"Summer Comforts" is the title of a pamphlet on fan motors, sent out recently by the Fort Wayne Electric Works, of Fort Wayne, Ind. The pamphlet illustrates and describes desk, revolving, dragon bracket, universal bracket, and telephone booth fan motors for direct-current and alternating-current circuits. Another pamphlet is devoted to direct-connected, direct-current generators for power and lighting, and shows both the detail parts and the complete machines.

A new flush push-button switch, manufactured by the Stanley-G. I. Electric Manufacturing Company, of Pittsfield, Mass., is dealt with in a bulletin recently issued. The switch is made in single-pole, double-pole, three-way and four-way types, and may be safely used on 250-volt circuits. The movement is rotary, combining a short push with a positive action.

The interpole motor built by the Electro-Dynamic Company, of New York, is illustrated and described in a circular recently issued. This motor is built in sizes up to 150 horse-power for either constant or variable-speed service, and is made either open, semi-enclosed, or fully closed, and in horizontal, vertical, elevator, and hoist types.

Instruments manufactured by the Wagner Electric Manufacturing Company, of St. Louis, Mo., are illustrated and described in a folder. The list includes standard types of wattmeters, ammeters, transformers, multipliers, portable volt-wattmeters for lamp testing, combined voltage and frequency indicators, and power factor indicators.

The construction and operation of gas engines built by the De La Vergne Machine Company, of New York, are described in a new catalogue. A number of gas and oil engines, and a suction gas producer are also dealt with. Single-cylinder, four-cycle engines are built by them in sizes from 50 to 175 H. P., two-cycle, double-acting engines in sizes from 500 to 3000 H. P., and oil engines in sizes from 5 to 250 H. P. A forty-eight-page pamphlet describing various types of horizontal and vertical ammonia compression refrigerating machines and equipment for ice plants, breweries, packing houses, etc., was also recently issued by this company. The book is illustrated by many fine half-tones, a feature of these being the arrangement of composite views of plants installed in various parts of the world.

C. E. F. Ahlm, consulting and designing engineer, of Cleveland, Ohio, has lately sent out a pamphlet, calling attention to the specifications, designs, and reports executed by him, and showing samples of his work.

Alternating and direct-current motors built by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., for all classes of service, are dealt with in a circular recently issued. The circular is known as the "Convention Edition," and contains a list of Westinghouse motors in convenient form for reference.

Direct-connected Corliss engines, built by the Allis-Chalmers Company, of Milwaukee, Wis., are dealt with in a recent bulletin. The pamphlet emphasizes the steam economy and high efficiency of these engines, and the small floor space required. Another bulletin is devoted to alternating-current generators of the belted type, and data is given showing the output, speed, and voltage.

M. W. Dunston & Co., of Providence, R. I., are mailing samples of cotton sleeving and tape for electrical purposes. The samples show the sizes, quality, and colours of these materials carried in stock.

The Von Zweigbergk Controller Company, of Cleveland, Ohio, in a recent bulletin, describe the metallic shield blow-out arc-rupturing devices made by them. These controllers are adapted for street railway work, and for cranes and hoists. The blow-out coil is located in the centre of its field of action, making the apparatus compact and simple. The process of rupturing an arc by this method is clearly explained in the bulletin by aid of diagrams.

The Manhattan Electrical Supply Company, of New York, announce, in a unique folder, their new location at 17 Park Place,—only 45 seconds from Broadway. Information is given how to reach them from New York and surrounding towns. Their motto is, "Something Electrical for Everybody."

The Leeds & Northrup Company, of Philadelphia, Pa., have recently sent out an attractive circular containing an illustrated description of their new shop and laboratory at Philadelphia. The increased floor space has enabled them to make extensive additions to their equipment of machine tools and standardizing apparatus for turning out condensers, galvanometers, bridges, resistance standards, testing keys, potentiometers, electro-dynamometers, and portable testing sets.

A series of bulletins recently issued by the General Electric Company, of Schenectady, N. Y., are devoted to "GE-87" railway motors, type "H" subway transformers, small polyphase motors, direct-current motor-driven air compressors, and Curtis steam turbine generators of the horizontal type. These units are built in sizes of 15 KW., 20 KW., 25 KW., 75 KW., 150 KW., and 300 KW., and can be arranged either for non-condensing or condensing operation. The 15-KW. unit for train lighting has already been described in these pages. A folder also issued deals with the Edison reflector lamp. This lamp has a rather flaring bulb, the upper half of which is coated with a heat-proof silvering, forming a very efficient reflector. Other literature consists of a pamphlet of parts of plain type carbon feed enclosed arc lamp, cast grid field rheostats, and moulding rosettes.

Railway motors for direct-current service are illustrated and described in a pamphlet recently issued by the Westinghouse Electric & Manufacturing Company, of Pittsburg. The various details are shown in the illustrations and efficiency curves are given for various gear ratios. Electrical and mechanical brakes for type "K" motors are dealt with in another pamphlet. Sectional views show the arrangement of parts, and illustrations are also given of motors and brakes applied to Wellman, Seaver, Morgan charging machines.

One of the means for recreation provided for the Bell telephone operators in Boston will be a roof garden.

Electrical Development in South America

THAT there is a healthy growth in the installation of electrical machinery in South America is well shown by several activities in Peru and Brazil. The Empress Electrica de Santa Rosa, Peru, which already operates a large generating station on the River Rimac, is extending its service to such a degree that an additional power house is necessary. This will be operated in parallel with the present station.

The equipment for the new station includes two three-phase, 60-cycle, revolving-field, alternating-current generators, each having a capacity of 1200 kilowatts and operating at 2300 volts. The generator voltage will be stepped-up in three 750-kilowatt water-cooled transformers to 33,500 volts, and transmitted to a sub-station where distribution will be made from water-cooled step-down transformers at 2300 volts. The electrical equipment, including generators, transformers, switchboards, and auxiliary apparatus, has been ordered from the General Electric Company, of Schenectady, N. Y.

In Brazil, the Sao Paulo Tramway Light & Power Company is also making additions to its present equipment. At the generating station another General Electric three-phase, revolving-field, 2000-kilowatt, 2300-volt generator is about to be installed, with necessary switchboards for the operation of the new machine. In addition, the equipment will be increased by three 60-cycle, 666-kilowatt, 24,000-2000-volt transformers and three 60-cycle, 666-kilowatt, 20,000-2300-volt transformers of the same type. This power house furnishes current for the railway, and for light and power. The railway equipment is being increased by ten double-motor car equipments, and one four-motor equipment.

Another interesting installation about to be made in Peru is at the mines of the Inca Mining Company. The location of the properties of this concern makes transportation very difficult, and all material has to be packed up the mountain trails on mules. The electrical equipment includes a three-phase, 200-kilowatt, 6600-volt, alternating-current generator of the revolving-field type. In addition, there will be four 67-kilowatt transformers, as well as several induction motors for hoisting work, and the necessary switchboards. The complete equipment will be furnished by the General Electric Company. In order to facilitate transportation, all the apparatus will be constructed in parts, none of which will weigh over 350 pounds, except the alternator shaft. The work of assembling the machinery will be done at the mines.

International Association of Municipal Electricians

THE eleventh annual convention of the International Association of Municipal Electricians will be held at New Haven, Conn., August 15, 16, and 17. Among the papers to be read are the following:—

"History of the Fire and Police Telegraph," by Adam Bosch, of Newark, N. J.

"Details of Certain Auxiliaries to Fire-Alarm Apparatus," by J. B. Yeakle, of Baltimore, Md.

"Advisability of Protecting Municipal Electricians by the Civil Service Laws," by Jerry Murphy, of Cleveland, Ohio.

"Comparison of Underground and Overhead Wiring, and of the Relative Values of Single Rubber-Covered Wire and Lead-Encased Cable for Underground Construction," by W. H. Thompson, of Richmond, Va.

"Conditions Surrounding the Inspection of Wires in the Southwest," by Clarence R. George, of Houston, Tex.

The question box is in charge of W. M. Petty, of Rutherford, N. J.

According to "Stahl und Eisen," North America's coal deposits are estimated at 681,000,000,000 tons, Germany's at 280,000,000,000, Great Britain and Ireland's at 193,000,000,000, Russia's 40,000,000,000, Belgium's 23,000,000,000, France's 19,000,000,000, and Austria's 17,000,000,000. Europe's total is given as 700,000,000,000, while that of Asia is too great to be even estimated. China and Siberia are also noted for large coal deposits. Germany's deposit, it is estimated, will last 2000 years, while that of Great Britain and Ireland would last only 400 years, as the consumption is twice as great.

The operating efficiency of the electric elevator, says S. M. Bushnell, in "Cassier's Magazine," is about twice that of the hydraulic, and when we add to this the enormous difference in first cost, the argument becomes very strong in favour of the electric elevator with central station service.

High-Voltage Direct-Current Lines on the Continent

In view of the experiments now being made in this country with direct-current motors using potentials above the present standard, it is interesting to note, says "The Street Railway Journal," that in Germany and other countries, the Siemens-Schuckert Works have completed, or have under construction, a number of lines of this character. At the present time they are building several lines exclusive of the 1000-volt Cologne-Bonn Railway, and the Berlin elevated and subway lines, which use 800 volts.

One contract covers various branches of the Cologne suburban lines, which are to employ 700-800 volts direct current. On the Castellamare de Stabia-Sorrento (Italy) line, an operating current of 825 volts will be used, and also one of 750 volts at the center of the line. This system will be 12 miles long, have a 3-foot 1½-inch gauge, and with a maximum grade of 6.2 per cent. and a minimum curve of 49 feet. The highest speed at which cars will be run will be 18.6 miles per hour. Current will be taken through trolley bows. At present there are twelve cars in operation, carrying 50-H. P. motors.

Another line under construction is the Moselhütte Freight Railway (Maizieres-St. Marie). It will be 9 miles long, and will use 2000 volts direct current. A freight railway is also being built for the Anhalt Coal Works, Reppist, near Senftenberg. This is to be a 900-volt line, 4 miles long, 4 foot 8½-inch gauge, with a grade of 1 per cent.

Single-Phase System for the Erie Railroad

At a recent meeting of the board of directors of the Erie Railroad it was decided to take the initial steps of operating electric trains by contracting with Westinghouse, Church, Kerr & Co. for the installation of an electric system on its Rochester & Mount Morris Division, a distance of 35 miles. The company's electrical board, which consists of J. M. Graham, B. J. Arnold, L. B. Stillwell and A. C. Williams, has had the matter under advisement for a period of two years. Mr. Graham has been on a personal tour of inspection of electric railway systems in this country, as well as in Europe. The Westinghouse single-phase alternating-current railway system, which is now being installed by the New York, New Haven & Hartford Railroad Company, is to be used. The preliminary contract calls for the electrification of 35 miles of the company's line from Rochester to Mount Morris, the equipment of a transformer station, and the installation of seven electric cars. These cars will be operated by single-phase motors, probably four of 150-H.-P. capacity each to one car. The line construction will be of the single-phase catenary trolley type. The cars will be used to haul passenger as well as freight cars. The power for the operation of the road is to be obtained from the Niagara Falls Power Co.'s plant.

Steinmetz on High-Speed Electric Railroading

In the New York "Sun" of recent date Charles P. Steinmetz is quoted as saying that up to 150 or 200 miles an hour there is no limit to the speed that may be developed in electric traction. Higher speed than that the car wheels could not stand, as they would fly to pieces from centrifugal force.

His remarks were called forth by the publication in a Philadelphia newspaper of an article doubting if much higher speed could ever be used on the railroads than that which is attained now. It was pointed out that the first cost would be enormous, entailing a higher fare between cities, but more important was the question of signals. The engineer, it was said, could not see the signal in time to stop the train if it was going at a high rate of speed.

"Not only can a speed of 120 miles an hour be maintained on a train equipped with electricity," said Mr. Steinmetz, "but in my opinion it is an entirely feasible scheme from the commercial point of view.

"It is largely a question of roadbeds, and signals have little or nothing to do with it. Of course there is danger from high-speed trains, and probably there always will be, but the tendency is not only to increase the speed but to make the railroads safer. This is illustrated by the gradual abolition of crossings at grade and the elimination of sharp curves. I presume that the time will come when grade crossings will be done away with entirely and the railroads so ballasted and straightened out that a speed of 120 to 150 miles an hour can be maintained.

"As a precaution against collisions the high-speed electric railroad would have to be built in 15 or 20-mile sections with sections a mile or two long in between, which could not be crossed by a train while another train was in the section ahead. These short sections could be so equipped that the power would be cut off as long as there was a train in the long section ahead. The result would be that the train following would come to a standstill until the train ahead got out of the block. However, these are mere matters of detail which I am confident could be adjusted to provide for all emergencies.

"In my opinion we are fast coming to electricity in place of steam, in all densely settled sections at least."

The Flaming Carbon Arc Lamp

In the paper, by L. B. Marks, on "The Flaming Carbon Arc Lamp," reprinted in the July number of The Electrical Age, the table on page 26 should give the cost of carbons for two enclosed arc lamps as $2.86 instead of $2.68. This will make the total $8.50.

In justice to Mr. Marks also, we wish to say that Figs. 2, 3, 4, 6, 7 and 8 did not appear in the original paper, but were added as being perhaps of additional interest.

The value central station men place upon the convention papers of the National Electric Light Association is strongly evidenced by the large number of orders sent in for sets of these papers and the Question Box. The programmes are now so large and the expense of printing so heavy that it is found impracticable to make free distribution of the papers, before they are issued in book form, except to members attending the meetings. Although the transactions are distributed as promptly as the character of the publication will allow, a large proportion of the members are glad to pay the cost of printing and mailing in order to have copies of the papers at once, and the secretary's office has been kept busy filling orders for them.

A new railway, now being constructed between Portland and Seattle to supplement the present Northern Pacific line between those cities, is to be operated by electricity. This is the first instance in which one of the large steam railroad systems in the West has adopted electric traction.

Power Required by Motor-Driven Machine Tools

By G. M. CAMPBELL

From Paper Read Before the Mechanical Section of the Engineers' Society of Western Pennsylvania

IN machine tool work speed variation is essential, and in a machine driven by an individual motor part of the speed variation must be obtained in the motor itself if efficient speed control is required. The range of speed required in some machines may be quite limited, on account of the particular class of work for which the machine is used, and in such a case the full range of speed could be supplied by the motor. On the other hand, the speed variation required may be so great that it is impossible to supply it all by the motor.

Just what range of speed is required in the motor can not be definitely stated for all conditions. If a total speed range of six to one is required in a machine, it might be advisable under certain conditions to obtain this total range in the motor, but as a general rule the writer believes it would be advisable to use at least two runs of gears when the speed change required exceeds four to one, and that a somewhat better and more efficient design can be obtained when the speed change required in the motor is limited to about three to one.

The controller necessary to enable the speed change to be obtained in proper increments will vary according to the range required and the size of the increment. It is feasible to work to within ten per cent. change of speed and consequently a ten per cent. increment would be desirable. If ten per cent. increment is used the number of points of the controller would be obtained from the formula:

1.1^{n-2} = speed range in motor.

Here n is the number of points in the controller, "off" point being counted as one point. This would give results as follows:—

Speed Range.	Controller Points.
3	14
4	17
5	19
6	21

If the motor is a reversing one then to this number of forward motion points must be added the required number of back motion points, usually one-third to one half the number of forward, so it is seen that the controller would become unwieldy in size or the speed increment would have to be increased above ten per cent. In the Pittsburg & Lake Erie Railroad shops the speed increment was about ten per cent. and the speed range required in the motor somewhat less than three to one, the necessary number of runs of gears being used to give the total range in the machine. The maximum number of runs used was four.

Other conditions being the same, the power taken by a machine, after allowance is made for friction losses, will vary approximately as the speed and cut and therefore as the weight of metal removed; consequently, in fitting motors to tools, due allowance must be made for high speeds and maximum cuts, bearing in mind the coming universal use of high-speed tool steels and the increase in rigidity of machines. A formula for the amount of power absorbed in cutting may be stated thus:

H. P. = K. W.

where H. P. = Horse-power
K = A constant, depending on the kind and grade of material.
W = Weight of metal, pounds removed per minute.

Values of K may be taken as follows:—

K = 2.5 for hard steel.
= 2.0 for wrought iron.
= 1.8 for soft steel.
= 1.4 for cast iron.

This formula is simply a general one; the power required in any particular case will vary perhaps 100 per cent. according to the condition of the cutting tool.

Another factor which enters into the capacity of the motor required is the friction loss of the machine itself; this is a factor impossible to predetermine, but fortunately is not very large except on very large machines; it depends greatly on the gear reduction. The accompanying diagram, Fig. 1, gives a typical example of friction losses and shows the general run of such losses; the power lost in other machines may be assumed by comparison. It is for a twenty-inch by eleven-foot Putnam lathe, gear reduction varying from 3-1 to 80-1. The maximum loss is about 1.2 horse-power. The loss in friction is not directly proportional either to motor speed or spindle speed.

Fig. 2 shows the power lost in a sixty-inch planer, Fig. 3, in a punch. These curves show that the losses are small, except when the spindle or table is running at top speed. At the high-spindle speed it is rather unlikely that a maximum cut is to be taken, but in all probability only light finishing cuts or polishing, so that in general the power lost in friction in the machine may be neglected in considering the question of size of motor required.

There is a class of machines where

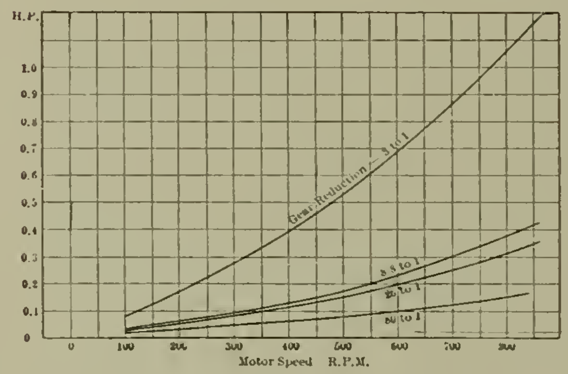


FIG. 1.—POWER LOST IN FRICTION IN A 20-INCH LATHE

the size of motor required depends very largely on the machine itself, almost independent of the size of cut it has to take; this is the reciprocating tool, as the shaper and planer, and to a somewhat less extent the intermittent working machines, such as punches and shears. In planers where shifting of belts is relied on to reverse the motion, the statement is fairly accurate; in tools where the reversal takes place by magnetic clutches or motor reversal it is not so much so, as the power taken by the motor can be better regulated. In planer drives where motors run continuously in one direction, it is of relatively little importance how much the platen or the load on it weighs, but the size and weight of the revolving pulleys which have to reverse it are of very great importance. These pulleys should be as small and light at the rim as capacity will allow; and on one of the revolving shafts, preferably on the motor shaft,

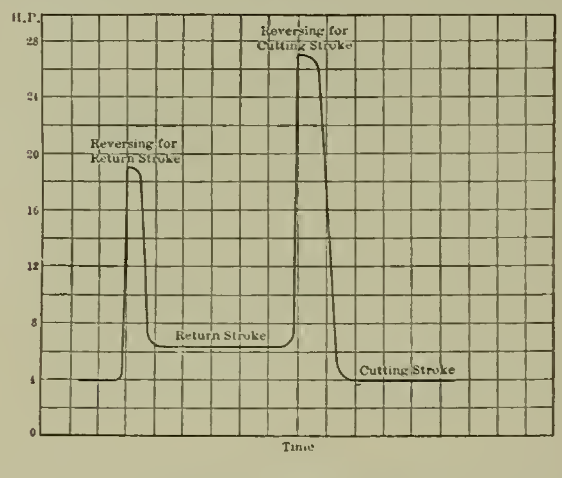


FIG. 2.—POWER CONSUMPTION OF A 60-INCH X 60-INCH X 20-FOOT POND PLANER, RUNNING LIGHT

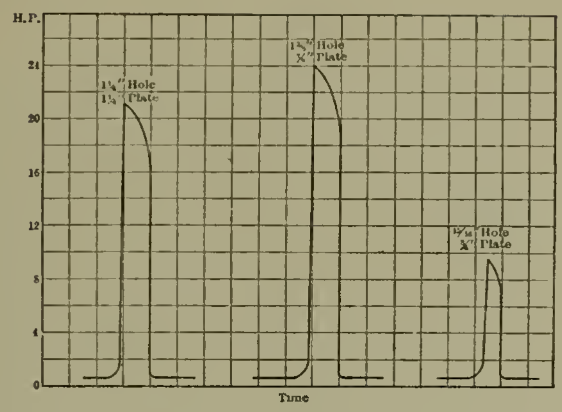


FIG. 3.—POWER CONSUMPTION OF A HILLES & JONES PUNCH

there should be a fly-wheel of large diameter and heavy rim so as to aid the motor at moment of reversal.

Fig. 2 is for a 60-inch by 60-inch by 20-foot Pond planer. The cycle of power consumption is rather remarkable, but is a fair example of tools of this class and method of drive, reversal by shifting belts. These readings were taken with the machine running light. During cutting stroke the horse-power taken was 3.9, reversing to return stroke

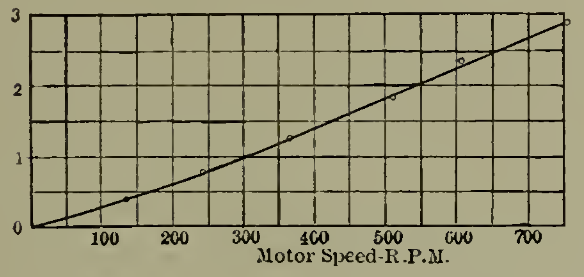


FIG. 4.—POWER LOST IN A 25-H. P. MOTOR

the power jumped to 19; on the return stroke it was 6.3 and in reversing to cutting stroke it rose to 27. The speed of the table in the cutting stroke was about 25 feet per minute; on the reverse stroke, 60 feet. This planer was driven by a compound-wound Crocker-Wheeler motor, 73.5 amperes, twenty horse-power at full speed and voltage rating. The fly-wheel on this machine is much too small, but, owing to special design of the driving mechanism, it could not be increased. The driving mechanism would have to be improved considerably to make it suitable for much higher speeds.

Influence of design on the power required for punches and shears is well brought out by Fig. 3. The horse-power rose to 21. The influence of the heavy flywheel and gear in another punch was sufficient to keep the power down to 7.9 horse-power on the same test.

In the shops of the Pittsburg & Lake Erie Railroad Company, at McKees Rocks, there are about eighty machines driven by individual motors. For variable speed work the speed variation required in the motor was, in general, about 2.8 to one for full power, but up to from six and seven and one-half to one for diminished power at low speeds, and the size of motor was approximately double the horse-power required by the machine throughout this full power range, i. e., if the motor was rated as a variable-speed motor, it would have a rating approximately one-half that of the constant-speed rating. The speed variation in many instances differed considerably from the above. In many of the drills, the

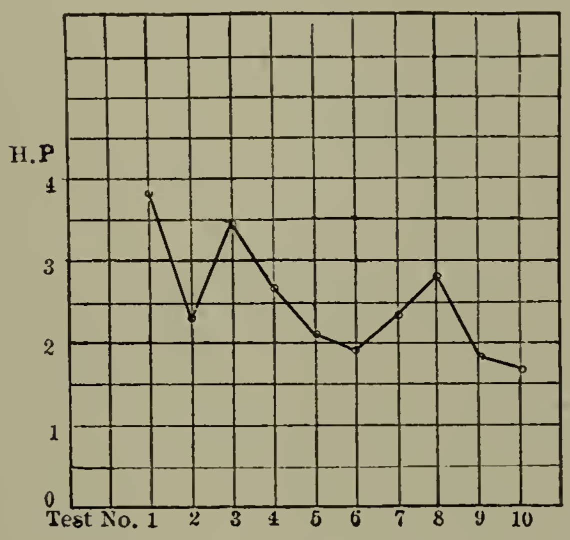


FIG. 5.—HORSE-POWER REQUIRED PER POUND OF METAL REMOVED

speed variation was higher and in planers, shapers, etc., lower. The speed control in these shops is obtained by means of the multivoltage system. The horse-power required by the machine was determined partly by general considerations and partly by the formula stated above, H. P. = K. W., where K had a value of 3.6 for hard steels and 2.5 for soft steels. From data given on a previous page, it may be seen that the size of this constant was on the safe side. All machines are protected by both circuit-breaker and fuses, the size of the breaker was, in general, four amperes per rated horse-power of the motor and it was set at the limit of 50 per cent. above this rating; the breaker would, therefore, fly out when the power consumption

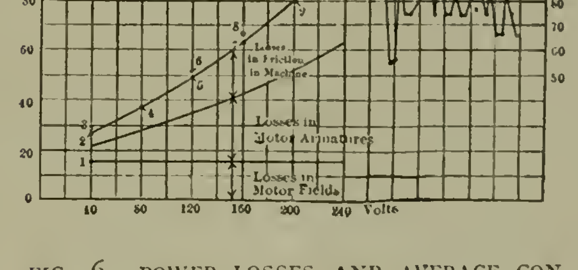


FIG. 6.—POWER LOSSES AND AVERAGE CONSUMPTION OF FORTY-SIX MACHINES WITH MOTORS OF AN AGGREGATE RATED HORSE-POWER OF 500

was approximately 100 per cent. overload. On reciprocating tools, the circuit-breaker was set 40 to 50 per cent. higher. The enclosed fuses used had a rating the same as that at which the circuit-breakers were set.

After the plant was in operation a large number of tests was made, every machine listed being tested to see whether or not the motor capacity was sufficient. In no case was the motor too small. In a few cases the motor could easily be reduced.

In making tests three separate sets were made:

1. Power required to drive the motor disconnected entirely from the machine, the motor being run at all the speeds. (Fig. 4.)

2. Power required to drive the machine on its different gear drives and different motor speeds.

3. The total power required during the time the machine gear drives and at different motor speeds.

This latter set of tests was taken haphazard, i. e., the electrician simply passed from machine to machine and took readings and record of the cut, no attempt being made to get the record at the best tool efficiency, consequently the records give every day shop practice such as will probably be met with in the ordinary shop. Practically all the tests were made in 1904, but only after the new shops were running and consequently the cuts and speeds given are much lower than present day practice. Nor was any attempt made to make tests when the machines were taking heavy cuts. These points must be borne in mind if cuts and feeds are examined.

After the tests were made, the first set would be compared motor to motor to see if all motors were equally efficient, then the first set would be subtracted from the second to obtain friction losses in the various machines and finally the second set would be subtracted from the third to find the actual horse-power taken by the cutting tool or tools. The curve of power lost by friction is given for a typical case in Fig. 1. As a sample, however, of the tests made, Table I. is given for a 72-inch boring mill. The horse-power given is the input into the motor, not the horse-power of the cut.

Table II. is of some of the readings taken on a 90-inch driving wheel lathe. After eliminating the power lost in friction and in the motor, the horse-power required to remove one pound of metal is given in Fig. 5; the amount varies from 3.87 to 1.70, certainly a very wide range, but the grade of steel also varies widely.

The total power lost in the motors and lost in friction in the machines is considerable, even though in individual cases it is not very large. To

TABLE I.—72-INCH BORING MILL

Motor—Type C. M., 25 H.-P. at 750 R. P. M., 230 V. 90.5 Amp.

R. P. M. of Table=2.35. 0.97 or 0.34% of Motor

Motor					Cut			Material			
Controller Point.	Voltage	Current	R. P. M.	H. P. Input.	Feed Inches	Depth Inches	Speed Ft. per Min.	Diam Inches	Weight, Pounds Min.	Kind	Remarks
18	240	4	--	--	--	----	--	--	--	----	Running light, table not turning
18	240	6	--	--	--	----	--	--	--	----	Running light, table turning
18	--	20	785	--	.125	.125&.125	--	19.5	--	Cast Iron	Two heads
21	233	28	970	8.76	--	----	--	--	--	----	Running light
21	233	38	978	11.88	.0625	.094	47	7.5	0.99	Brass	
21	232	37	988	11.51	.0625	.0625	47	7.5	0.66	----	
4	76	38	243	3.77	.0625	.375	28	58	2.05	Cast Iron	
9	116	16	361	2.49	--	----	--	--	--	----	Running light
8	76	49	340	4.98	.0625	.25	39	58	1.90	Cast Iron	
12	115	33	480	5.08	.125	.062&.031	44	44	1.24	Steel	
10	114	28	473	4.27	.125	.0625	42	44	1.11	----	
13	160	19	519	4.07	--	----	--	--	--	----	Running light
9	113	75	354	11.36	.125	.125&.125	51	52	5.41	Steel	
9	112	95	349	14.26	.125	.187&.187	48	52	7.65	----	
9	115	58	360	8.93	.125	.125&.187	47	52	3.75	----	
17	195	25	684	6.54	.125	.125	80	19	4.50	Brass	
21	234	35	964	11.00	.125	.094&.031	123	20	6.91	----	
20	235	30	915	9.47	.187	.031&.016	115	20	3.64	----	
20	236	20	930	6.33	--	----	--	--	--	----	Running light
20	244	13	940	4.25	.083	.125	33	18	1.07	Cast Iron	
6	78	26	294	2.72	.083	.125	33	18	1.07	----	
15	161	15	612	3.24	.062	.062	24	20	1.29	----	

investigate this point, among others, some experiments were made on a Sunday when the shops were idle. Forty-six machines were selected, every one equipped with an individual motor capable of speed variation. The machines were as follows:—

Machines	Horse Power Rating of Motors
17 lathes	215
5 milling machines and boring mills	70
5 planers	66
5 slotters and shapers	35
9 drilling machines	50
5 punches, shapers, rolls, etc	61
46	497

First, full-current strength was put on all the fields, then all the motors were run on the 40-volt circuit, then all on the 80-volt circuit, 120-volt, 160-volt, 200-volt and 240-

TABLE II.—90-INCH DRIVING WHEEL

Motor—Type C. M., 25 H.-P. at 750 R. P. M., 230 V. 90.5 Amp.

R. P. M. of Spindle=3.63, or 0.167% of Motor

Motor.					Cut.			Material.			
Controller Point	Voltage	Current	R.P.M.	H.-P. Input	Feed Inches	Depth Inches	Speed Ft. per Min.	Diam. Inches	Weight Pounds Min.	Kinds	Remarks
16	188	60	637	15.1	3-16	3-16 & 3-16	13.0	48	3.1	Steel	Double Head
13	157	50	430	10.5	3-16	5-16 & 5-16	8.8	48	3.5	"	" "
16	190	70	550	17.8	3-16	1-4 & 1-4	13.3	48	4.2	"	" "
13	156	45	540	9.4	3-16	3-16 & 3-16	10.9	48	2.6	"	" "
13	156	75	537	15.7	1-5	3-8 & 3-8	12.3	54	6.3	"	" "
13	156	70	536	14.6	1-5	3-8 & 3-8	12.3	54	6.3	"	" "
9	113	80	355	12.1	1-5	5-16 & 1-4	10.5	69	4.0	"	" "
9	114	77	363	11.8	1-5	1-4 & 1-4	10.6	69	3.6	"	" "
11	115	60	450	9.1	1-5	3-16 & 1-4	13.4	71	4.0	"	" "
17	196	46	728	12.1	1-5	1-4 & 1-4	15.5	51	5.3	"	" "

volt in turn, and finally lathes and drills were run on the high-speed point, approximately 30 per cent. above normal 240-volt speed, power consumption being noted at all the different points. All machines driven by these motors were in motion, but no work was being done, nor was feed mechanism in use. The results are plotted in Fig. 6; planer platens were not operating except for points 3, 6 and 8. The curve giving losses in motor armatures was plotted from readings on a number of motors disconnected from machines. The speed of the motors varies approximately as the impressed voltage, so it will be seen that after deducting 15.2 horse-power for the fields the horse-power lost in the motor-armature and tool varies approximately as the speed. It will be noted that when all these forty-six tools were running at top speed, no useful work being done, the lost horse-power was 105. The full losses given are never incurred as the tools are never all running at one time and never all on the top motor speed; in fact, the average or even the maximum power consumption on any working day when all the tools are working is less than the maximum for lost power alone. The part of curve at the right hand in the figure is the total power consumption for all the tools included above and a few constant speed motors besides. These readings were taken every two hours during the six working days succeeding the Sunday on which the readings for power losses were taken.

A large number of special conditions may enter into the determination of the size of the motor required for any particular tool, the class of work it is to be restricted to, the grade of material, whether cuts, if heavy, will be of short duration, etc., so that it is rather difficult to make a statement that will fit all cases, but the writer would suggest the following for determining the size of motor for average conditions:—Assume a cutting speed of 50 to 70 feet a minute for soft steels, estimate the maximum size of cut that will likely be required for any time longer than thirty minutes, transfer this into pounds of metal removed per minute and multiply by 2.7 (this figure is 50 per cent. above the constant 1.8 used previously in this paper, the increase being for safety for bad conditions), then select a motor which will develop this power throughout the range of speed desired.

The record is not quite complete as it does not give the gear reductions in use; some of the machines were using high-speed, some low-speed gears. If all the machines had been run on the highest speed gear the loss in friction in the machines would probably have been doubled.

Electric fans and automatic valves are to be used for cooling the New York subway. Between the Brooklyn Bridge and Columbus Circle there are to be fourteen outlet chambers, each of which is to contain a fan and valve. Ordinarily, only the valves are to be used, the fans being reserved for excessively hot periods. The valves are operated by the increased pressure of air caused by passing trains; the escape of heated air between stations through the valves, which open outward only, causes an inflow of surface air at the stations and thus lowers the temperature.

In connection with the 1400-volt, three-wire, continuous-current railway recently constructed by him, Herr Krizik has devised the following method of speed control. At starting, current is taken from one side only of the three-wire system, the four motors and all the starting resistances being connected in series across that side. The resistances are gradually cut out, and then two of the motors. The latter are next connected in series with starting resistances and across the other side of the system; the resistances are then gradually cut out until full speed is reached and the four motors are in series across the outer conductors of the system.

THE ELECTRICAL AGE

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The Electric Home

By MAX LOEWENTHAL, E. E

A BED-ROOM IN THE HOME OF H. W. HILLMAN, OF SCHENECTADY, N. Y., SHOWING AN ELECTRIC RADIATOR, AN ELECTRIC HEATING PAD AND AN ELECTRIC FLATIRON

IN the pursuit of human happiness, the endeavour to raise the standard of efficiency of the home stands out supreme. Whatever will improve our domestic environments and lighten the labours of those entrusted with the cares of a household, adds to our happiness and becomes a material factor in furthering the progress of civilization.

It is true that the undue influence of sentiment has frequently retarded domestic progress, and this may be partially responsible for the limited use of mechanical, and especially electrical appliances in the modern home, a most deplorable fact, when one considers their many desirable qualifications, such as cleanliness, flexibility, safety and convenience, as well as the betterment of hygienic conditions.

If we reflect seriously, however, on the real causes responsible for this condition, we will find that the root of the evil is not sentiment to adhere to antiquated methods, or a lack of appreciation of improvements on the part of the "great, preoccupied, incredulous and indifferent public," as the great mass of the people have recently been termed. It is rather in the lack of foresight in the past on the part of the central station manager, who believed that his duty was completely and well performed after he had generated and transmitted current economically, never dreaming that the mercantile or business end of the enterprise which he was guiding, namely, the finding of a market for his product, was of equal and ofttimes greater importance. He either scorned, or was not acquainted with, the use of the salesman's tools and methods which in his particular case meant primarily the education of the public in the employment and possibilities of the electric current, the extension of his circuits into residential sections, the granting of special rates in particular instances, or for specific uses, and the fostering of local co-operative action on the part of the central station, the electrical contractor, the architect, the supply dealer, the electrical engineer, the manufacturer and the people.

That all these interests have come to realize the truth of this unfortunate state of affairs, namely, the extremely limited domestic employment of electricity, has been evidenced on every hand during the past year, for in almost every large city an "electrical residential campaign epidemic" has broken out. That a great deal of important work still remains to be done may be gathered from the startling fact, as shown by recent statistics, that the inhabitants of only 44 per cent. of 5000 cities have access to the electric current, not mentioning the small percentage of this 44 per cent which actually employs it.

The central station manager who talks about efficiency and price of apparatus should recognize the cardinal truth, that "it is not a problem of price, but of progress. It is not solicitation, but education that will open the market and make this class of apparatus more popular," education, not only of the public, but primarily of the central station soliciting force, for it is as important to know the limitations of one's product as it is to preach the gospel of its utility. Local conditions should be carefully analyzed and no advice

THE LIVING ROOM OF THE HILLMAN HOME, WITH AN ELECTRIC RADIATOR AND AN ELECTRIC CIGAR LIGHTER ON THE CHIMNEY MANTEL

given or statement made which cannot be substantiated or is not based on facts and figures.

Up to within a year, reliable data were not easily obtainable on which to base such statements, but since that time a number of comparative tests between various fuels and electricity under widely varying conditinons have been conducted and reported, and these, in conjunction with descriptions of actual domestic installations, working under normal conditions, may well serve as safe guides in the intelligent discussion of almost any electro-domestic problem. In view of this, the following description of a typical, up-to-date "electric home," which has, in every respect, come up to the expectations of its owner and may be said to have set to rest all doubts which may have been harboured in the minds of the most skeptical as to practicability of domestic electrical appliances, may be of interest and value.

This "spotless" electric home is that of H. W. Hillman, of Schenectady, N. Y. It is situated in a restricted suburban section of the city on Douglas road, on slightly elevated ground, so that from the veranda one may obtain a splendid view of the picturesque Mohawk Valley, with the southerly slope of the Adirondack range in the distance. It is a two-story frame cottage, built on a stone foundation.

IN THE SEWING-ROOM, THE MACHINE IS RUN BY AN ELECTRIC MOTOR, AND AN ELECTRIC PRESSING IRON IS A CONVENIENT DEVICE

This is the second residence which Mr. Hillman has erected in this section and the experience gained from the first has come in good stead in the construction and equipment of the second and larger home. The almost universal employment of electricity as the unseen servant who faithfully and tirelessly performs so much of the domestic work was due to the conviction, gained by the experimental use of electricity in the first house, that the utensils were efficient, durable and reliable, and that with careful handling the equipment was economical from the standpoint of operation as well as of maintenance.

In the planning of the house, Mr. Hillman had two sets of specifications prepared, one including the cellar excavation for coal and wood storage under the entire house, and a kitchen range with its inevitable chimney. The other specification was with only half the cellar excavated, the other half of the foundation only going down to the frost line, with no provision for a kitchen range and kitchen chimney, but including the installation of heating and cooking circuits and outlets in addition to the lighting circuits. When the estimates were examined it was found that the difference in cost between the first and second plans was so much in favour of the second, that the amount saved was more than sufficient to purchase the entire electric kitchen equipment and all the other small electric utensils used throughout the house. The extra cost of wiring was about $125, or less than 1 per cent. of the total investment. Such an item of expense will never be considered in the wiring of houses costing $12,000 or more. This will certainly be true when prospective builders, architects and the householders have learned about the convenience and reasonable cost of operating electric household utensils.

It may be needless to state that the second plan was adopted, and, as the basement plan indicates, the cellar was excavated only in the rear portion of the house, the front half of the foundation having been carried down only to the frost line. In the excavated part, the furnace, not electric, but fed with coal, is located, and while ultra-enthusiasts may feel apologetically disposed in making this admission, it is far better to concede that electric house heating, at the present rates for current, is not practicable, than to make the attempt, fail, and be compelled perhaps to admit the inefficiency of the entire installation and thereby retard the progress of the domestic branch of the electrical industry.

The small amount of fuel which is required for the operation of the furnace during the winter months is stored in the limited space partitioned off toward the side of the house where the electric mains enter. In the small room adjoining the lighting and heating meters are located, and from here the mains ascend to the main distributing board on the second floor. Toward the rear of the house, in the basement, is the laundry, from which stairs lead to the electric kitchen on the first floor. Between this and the servants' quarters, is the pantry, as shown in the plan, on which is also indicated the lighting and heating circuits, as well as the outlets, fixtures and electrical utensils.

A spacious veranda or solarium extends along the entire front of the house and is completely enclosed by glass, which makes it an agreeable lounging space in winter, as it offers protection against cold winds and snow, permitting, however, the sun's rays to enter and assist the luminous radiator in making the place habitable. In summer the porch is shaded by numerous pine trees clustered around it.

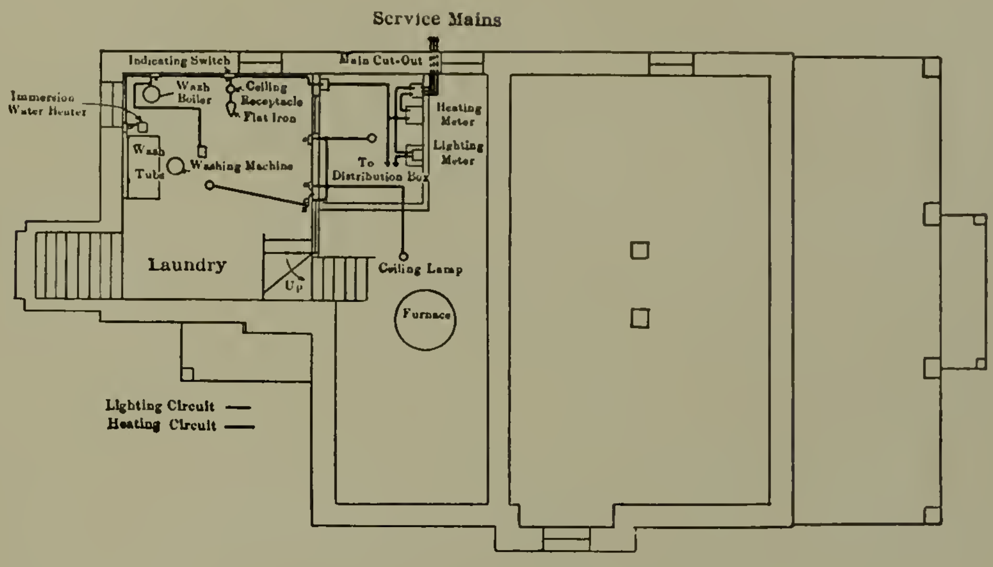
On entering the house and turning to the left, one finds himself in the very spacious, common sense living or music room, which occupies the one entire side of the first floor, while the dining room is on the opposite side of the entrance hall. It was sentiment which induced Mr. Hillman to install in the living room an eight-foot New England fireplace, around which his family and neighbours gather during winter evenings to discuss, beside other topics, their experiences with the numerous electrical devices. The mantel serves, furthermore, as resting place for the electric cigar lighter, as may be seen in the illustration.

On the second floor, as shown in the plan, are four bedrooms, the sitting room or library, and the bathroom. In the hall is the main distributing board for the electrical circuits. The service box is divided into two sections, each containing eight branch circuits, evenly balanced on the two sides of the three-wire system.

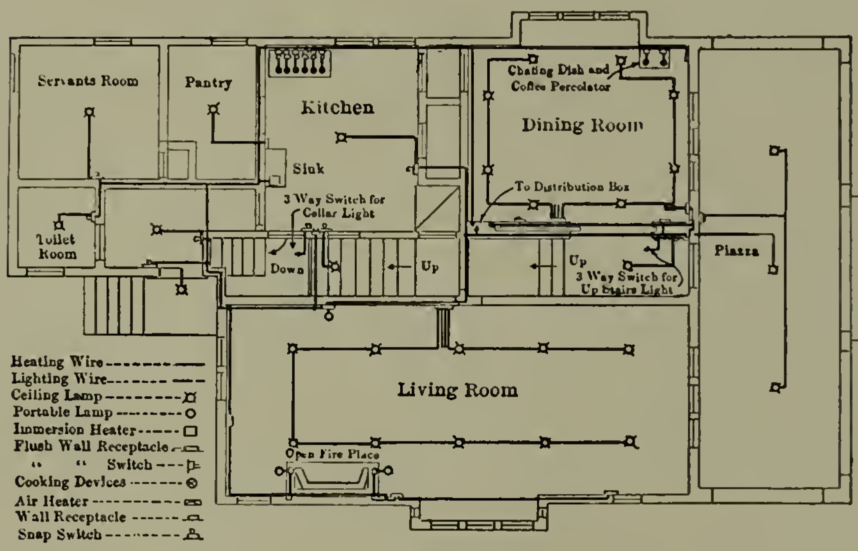
Before entering upon the discussion of the heating circuits, and the utensils which they supply with the current, it may be of interest to mention the unique and well-planned lighting system. A very pretty, cheap and convenient method of lighting has been adopted for the illumination of the dining room. Eight lights are placed in a cove ceiling, two on each side. The reflector type of lamp being used, the light is thrown down, where it is wanted, on the table.

Four switch buttons on the side wall control the lights in multiples of one, two and four, as may be desired. When all the eight lights are burning, the current consumed is practically the same as that used by four ordinary 16-candle-power lamps.

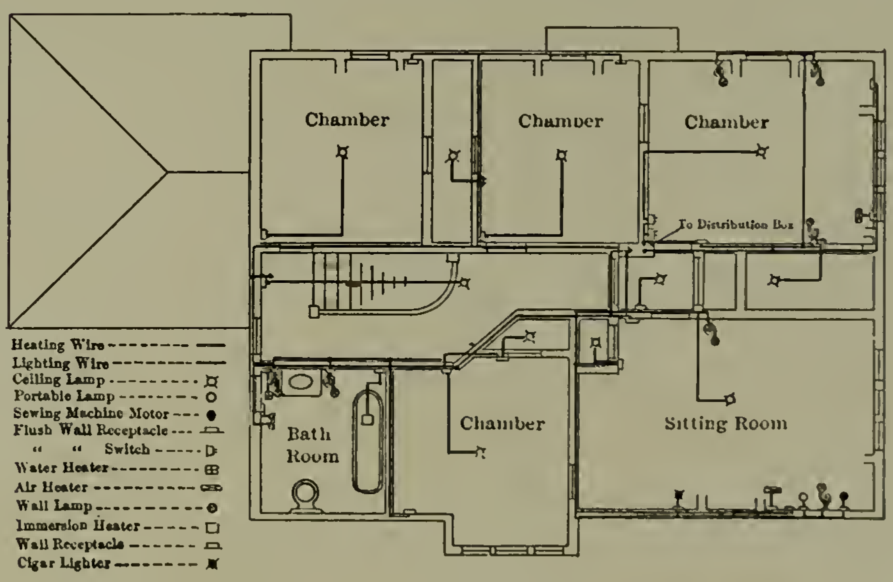
Special mention might well be made of the wisdom in installing the four sets of push-button switches, which greatly facilitate the exercise of economy in the use of the current, as the switching on of each



BASEMENT PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

A PART OF THE BATH-ROOM, WITH RADIATOR, MASSAGE VIBRATOR AND WATER-HEATER FOR SHAVING

additional set of lamps entails some manual labour, which the servant as well as householder prefers to leave undone. The extra cost of the subdivision of the circuit is easily paid for in a short time, by this enforced and actually demonstrated economy. As in the dining room, there are no lighting fixtures of any kind in the living room across the hall, which receives ample illumination from ten meridian reflector lamps attached to the ceiling beams, as shown in the illustration, while for reading or work requiring a more concentrated light the portable lamp shown on the side table is used.

Additional lamps of this type may be pressed into service by attaching them to plugs which fit into four flush receptacles in the baseboard around the room and two more located on the top of the fireplace.

Each of the other rooms on this floor is lighted by one ceiling light, separately controlled by a snap switch. There are three ceiling lights on the front veranda, controlled from the inside hall, one on the back porch, one over the basement stairs and three in the basement. In three of the chambers on the second floor ceiling lights have been provided, while the front chamber has three, and the sitting room two, additional wall lights. The bathroom is lighted by two wall lights, one on each side of the mirror, and each set of lights in the various rooms is controlled by a push-button switch.

A light is provided in each of the five closets on this floor, controlled by a button switch outside of the closet door. There is one light in the second floor hall and one even in the children's closet, which has been built under the stairs, on the first floor. In the words of Mr. Hillman, "It doesn't cost much and is convenient," which voices in a few words the why and wherefor of the many comfort-giving features about the house.

In a number of rooms the branch lighting circuits are tapped for the insertion of a flush wall receptacle, to which may be attached a great variety of electrical utensils, which consume up to 250 watts, such as the small electric food heater or shaving mug, curling-iron heater, Christmas tree outfit, heating pad, small pressing iron, sewing-machine motor, massage outfit, cigar lighter, ventilating fan and others, almost too numerous to mention.

Space also forbids more than a passing mention of the great convenience of the devices found in this modern home, for example, the cigar lighter, so thoroughly enjoyed by the men, and on account of the absence of matches from the house, so greatly appreciated by the ladies. It can be purchased for about $2.00 and it costs less than 1.10 mill to light a cigar. On the piazza it is a convenience, in the den it is ornamental as well, in the billiard room a necessity, and its low initial cost encourages its installation freely throughout the house. An important insurance authority recently remarked that the electric cigar lighter, if extensively used, would minimize the fire hazard from matches considerably.

Then there is the electric heating pad. Words fail to describe the value of this household utensil. The heat from the pad is uniform, compared with the varying temperature of the hot-water bag. It is adjustable for three heats. It will produce maximum heat for a perspiration effect, a medium heat, or can be kept under the bed cover all night at the low heat. The hot-water bag requires constant attention, or else it will become cold and uncomfortable and do more harm than good.

Among the up-to-date sewing-room appliances, the electric sewing-machine motor and pressing iron are most highly prized and become almost indispensable to the one who has used them. The cost of the motor, about $12.00, places it within the reach of every current user. Its operating cost is hardly more than one cent an hour. It is made to fit any type of sewing machine, and any lady can be taught to operate it in a few minutes. Many a backache, the writer is informed, has been saved since the machine has been available in this household. From the sewing room window, a dozen houses may be counted which are equipped with this convenient device.

In the same illustration will be noticed a small electric flat-iron, particularly valuable for sewing room use. It is difficult to state which device is prized most highly. They really go together. A sewing room in an up-to-date house would be incomplete without both. Many are the steps saved by having this iron ready at any time merely by the turning of a switch.

On the wash bowl, shown in the view of the bathroom, will be noticed a portable massage motor. The use of this article not only affords pleasure, but is well known that much benefit results from its intelligent application. It may be attached to any lamp socket and can be operated by any inexperienced person, by simply holding the motor by the handle and applying the applicator to the face, arm, neck, chest, or that part of the body where the stimulation is needed. Like the sewing-machine motor, the expense of operating it is trivial, while much benefit and pleasure may be derived from it.

The small water-heater, also shown on the wash bowl in the bathroom, is used as a shaving mug every morning. The bottom is simply covered with water, and while the man of the house is preparing to shave the water is heating. The push-button switch on the wall above the dish turns the current on and off, and should the current be left on by accident no harm will be done, as the dish is indestructible. The operation of heating the water for shaving costs about one mill and the device may be purchased for from $3.75 to $5.00, depending upon size and style.

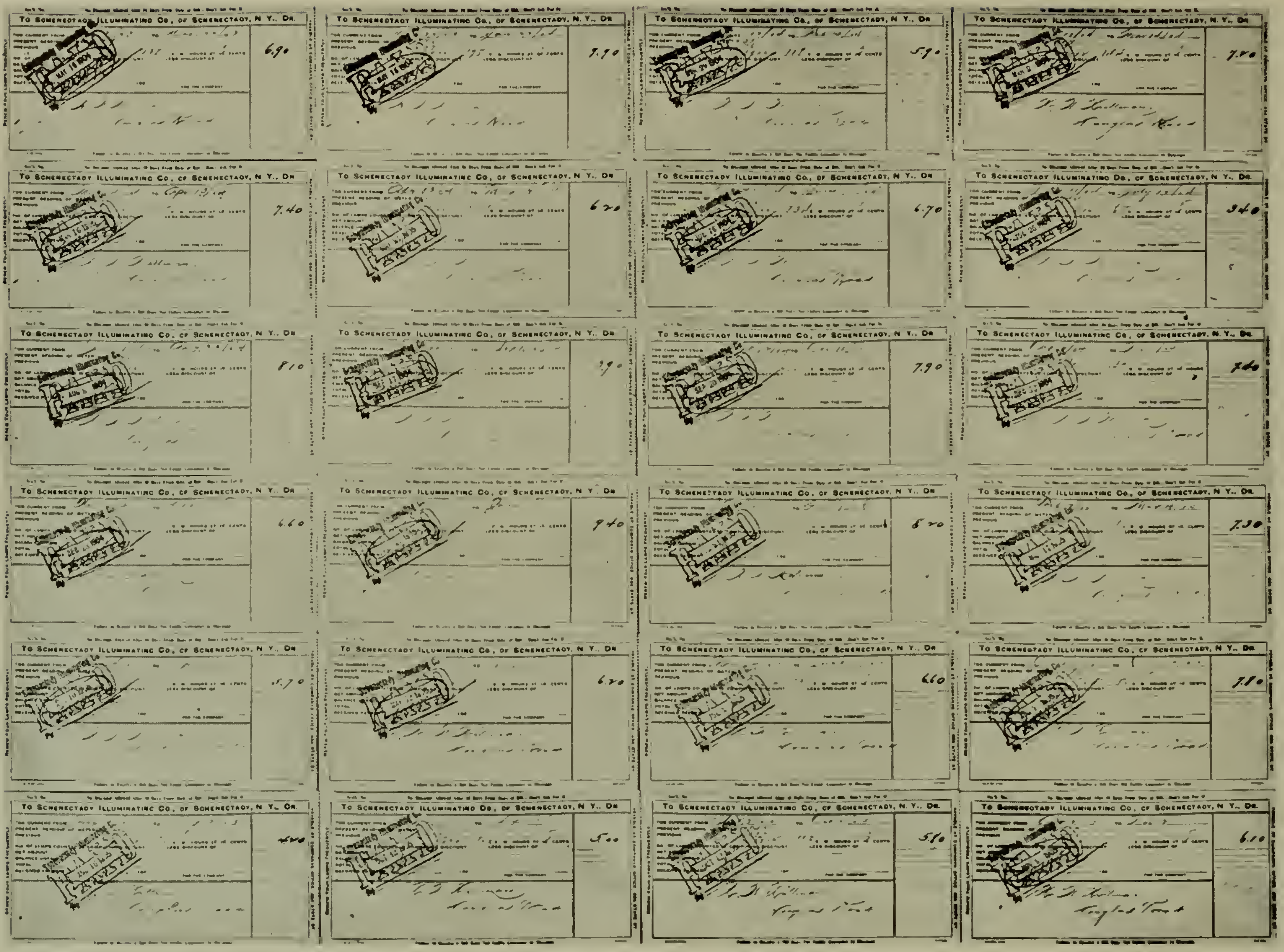
It will thus be seen from the foregoing that the function of lighting circuits may be extended a great deal further than the mere furnishing of current for indiscriminately distributed lights. The complete realization of their scope of application and some forethought during the planning period will insure for the intelligent household many benefits and comforts at a low initial and small operating cost. If, in addition to these circuits, separate heating and cooking circuits are available, as they are in this house, then the full blessings of electricity in the home may be realized and appreciated.

In the dining room, for example, we find the coffee percolator and chafing dish, the romance of which might be disturbed, at the very moment when a jolly evening gathering might be expectantly seated around the table, by a flash in a lamp socket which was not designed to carry the current required by a chafing dish, or by the blowing of a fuse on a lighting circuit. To avoid so disastrous a mishap and in view of its great convenience, a special table has been installed which is quite interesting. It is much like any ordinary side table, of quartered oak to match the dining room finish. A small backboard to the table supports two sockets, or receptacles, the wiring and the on-and-off switch. The flexible cord leading from this switch has at the other end a plug which fits into any one of the several heating circuit receptacles in the baseboard around the room. These tables have become so popular that they are now carried in stock by a local department store, and sold at something like $1.00 or $1.50 above the regular price.

It was, however, mainly for the

IN THE KITCHEN NO GAS OR COAL IS USED. EVERYTHING IS COOKED BY ELECTRICITY

THE LAUNDRY, SHOWING FLATIRON, WASH-BOILER AND IMMERSION-COIL HEATER



TWENTY-FOUR BILLS FOR CURRENT, SHOWING THAT THE MONTHLY AMOUNTS RANGED FROM $3.40 TO $9.90. THE AVERAGE IS $6.62

purpose of performing, within certain limitations, the three indispensable operations in the household, for which fuels such as gas or coal, or both, are ordinarily employed, that the heating circuits were installed. These are the heating of water for bathing and washing purposes, ironing the wash and cooking the food. That these functions have been satisfactorily and economically performed by means of the electric current, Mr. and Mrs. Hillman are prepared to state after two years experience, and this testimony is amply borne out by the figures which are presented herewith.

During the winter months the hot water front on the furnace, furnishes hot water for the two bathrooms, kitchen, laundry, etc. Such water fronts are commonly installed by the furnace people and the extra expense amounts to almost nothing. In this case, it was $8.00 or about 2 per cent. above the contract price of the heating system without the water front. During the summer months, say from the first of June until October first, an electric immersion coil heater, shown in the illustration of the laundry, is used to heat the water in the bath tub.

The temperature of the bath water required by the average person is from 95 to 100 degrees F., and the temperature of the water running through the mains in Schenectady during the summer months will average 65 degress, F. A hot bath can be secured in from 20 minutes to a half hour, at a cost of from three to five cents. Considering the few months of the year when the furnace is not operating and the vacation days when the house is closed, the expense, as cited, does not unduly increase the monthly bills.

While on the hot water proposition, our thoughts are naturally directed to the laundry and the writer deems it best to quote Mr. Hillman's own words in relating the family's laundry experiences. "For ten years," he says, "the coal range has done duty in connection with washing and ironing; the gas range performed good service for six years, but on Mondays and Tuesdays it was considered advisable by the women folk to wash and iron by the coal range. The servant always had a red-hot fire on ironing day, and used three or four flat irons. The common objection was raised as to the heat from the stove during the hot days, and the taking of many steps from the stove to the ironing board, it being natural to get as far away from the stove as possible, to avoid the heat.

"It cost from nine to fifteen cents for the coal consumed. The electric iron has been used by us for twenty-six months and represents a most popular article. It costs about $3.75 to purchase; the ironing can be finished more quickly and handled more comfortably on a hot day; it saves steps and the operating cost for the same work is about twelve cents. During our experience with electric devices, the coal range continued to be necessary until some months ago, when an immersion coil was tried for several weeks. This was convenient, but expensive. It was superseded by a special electric wash boiler, having a capacity of nine gallons. The cost of operating this was twelve cents per week, or forty-eight cents more expensive per month than the coal range.

"The latest and best arrangement, however, is the washing machine operated by an electric motor, which is about to be installed. Our family experience cannot be given, but it will be interesting to know that a wash of the size of ours can be finished in three-quarters of an hour, compared with the entire morning in the old way. The expense will be less than five cents for the current used." As the illustration of the laundry shows, the flexible cord leading to the iron is attached to a keyless ceiling receptacle, which is controlled by an on-and-off indicating switch on the wall. Two other switches of the same type control the current which operates the wash boiler and immersion coil.

The illustrations of almost every room show what is known as the luminous radiator, as the three large heat-giving lamps also produce light, and on account of the rapidity with which heat is emanated it is sometimes called the "instantaneous electric heater." During October the weather in Schenectady is almost too warm for a hot furnace fire, yet it is sufficiently cold to require some heat daily, especially in the morning and at night. The four heaters installed, therefore, were used quite a little for auxiliary heat during that month.

Early in the morning, also, before the furnace fire is burning well, it is pleasant to switch the radiator on for fifteen minutes, let us say, in the bathroom while shaving. It costs about two cents for electricity. The initial cost of the heater is about $10.00 or $12.00, depending upon size and finish. It is portable and can be used anywhere in the house, as the plugs to which the flexible cords are attached are interchangeable and receptacles are located all over the house to meet such requirements.

Having now acquainted ourselves with all the miscellaneous electric utensils used about the house, we come to the kitchen, perhaps the most interesting feature of the house on account of its very complete electrical equipment and the absence of a coal, as well as a gas, range. As the plan and illustration of the kitchen show, a small table, resembling an ordinary kitchen table, measuring 3½ feet in length, 2 feet in width, with a projection at the back, 12 inches high, and a shelf near the bottom, stands in the corner between the window and the pantry door.

IN THE DINING-ROOM A COFFEE PERCOLATOR AND A CHAFING DISH ARE PLACED ON A SIDE TABLE PROVIDED WITH SOCKETS AND A SWITCH

Mounted on the front of the projecting board are eight on-and-off snap switches. Six switches for the control of the various cooking utensils may be seen on top of the table, and below are one for the oven and the small switch for the light within the oven. Below the switches on the board are six holes through which the flexible cords pass, to the ends of which the terminals fitting the utensils are attached. The other ends of the cords enter the switches at the back of the board where all the permanent wiring terminates in a fuse block. From here a flexible cord with a plug at the end leads to the baseboard receptacle.

The cooking and baking outfit, which has been in use over two years, consists of an oven, a cereal cooker, frying pans, vegetable boiler, stoves, gridiron and meat broiler. When one considers the convenient design of the devices, the majority of which are made of aluminum, besides the features of economy, safety, cleanliness and portability, one can appreciate the pleasure experienced in this household by their use.

The oven, for example, is equipped with a regulating switch for securing high, low and medium heats by the turn of a handle. In size, it has about the same inside dimensions as the old-style kitchen stove, or later designs of gas ovens. A novel feature of this oven is its equipment with two glass windows in the door, through which one may watch the progress of the roasting or baking operation without opening the oven door. This is made even more convenient by the turning on of an incandescent lamp secured inside of the oven.

To appreciate how satisfactorily the oven bakes it is only necessary to listen to the verbal testimony of Mrs. Hillman, who will, at the same time, show you a loaf of bread, some cookies, or a batch of doughnuts which have been cooked perhaps the same day. In reading this one must appreciate that the person who has operated this outfit entirely since its introduction is a young Polish girl of ordinary intelligence. For two consecutive Christmas dinners the electric oven has been tested with very gratifying results. A fourteen-pound turkey prepared in an excellent manner gave ample evidence of the efficacy of this system of roasting.

The electric gridiron is 9 by 12 inches in size. It requires but two minutes to get it hot, after which the most delightful brown cakes may be fried on it.

The meat broiler is equally pleasing to handle, the heat regulation being effected by means of a three-heat switch. The cereal cooker is a four-combination device. When getting breakfast, it is the first used for heating water for coffee, and then it is used as a cereal cooker. When that is cooked, the interior dish is removed and the eggs are boiled or steamed, using the boiling water then available. Later in the morning the potatoes are steamed,—not "water soaked" by boiling.

When steam is thus utilized, a small quantity of water is sufficient, and the device uses less current and requires less time for cooking. In the writer's presence, for example, Mr. Hillman boiled, or rather steamed, an egg to medium hardness in the following manner: Instead of putting a cup full of water into a pot or enough to cover the egg, as is usually done, he simply put in a tablespoon of water. After one minute, most of this water had been transformed into steam and the egg was then inserted, the steam completing the operation in another three minutes. This incident is cited in order to point out the economy which may be effected in the use of current if intelligent use is made of the utensils, and they be disconnected from the circuit as soon as the cooking operation is completed.

The simplicity of this function, namely the mere turning of a switch handle, and the fact that the food would be spoiled if the current be left on, is one of the inherent advantages of this system of cooking. The careless habit of the gas stove operator to leave the several gas rings turned on, when there is no further need for them for quite some time, setting the pots with food in them to one side, is thus obviously prevented by the use of these utensils with their self-contained heaters. The frying pan and vegetable boiler are used frequently, particularly the frying pan, which becomes well heated in about a minute, and is mostly used for frying bacon and eggs.

For the washing of dishes and utensils, during the summer months, hot water is obtained by the use of an immersion coil, there being a receptacle near the sink for this purpose. An almost momentary use of the current is made for the drying out of the cooking utensils.

Curiosity has doubtless been aroused before reaching this point as to the cost of operating all the electric heating, cooking and miscellaneous devices described above. This question, whether asked by the layman or central-station man, should be answered fully and frankly, for the immediate future of this branch of the electrical industry depends largely upon the dissemination of data based on the practical results obtained by the public and not the presentation of tables compiled in the laboratories by investigating committees. This is not so much a question of thermal efficiency of the utensils, or a comparison between gas and electric appliances, as one of actual cost of operation under normal working conditions, and no theoretical discussion can possibly take into account the ever-varying conditions which develop when customs change, as well as the personal factor which enters so largely into culinary operations,—considerations, which, though unmeasurable, are as vital almost as the question of cost of current.

While numerous laboratory tests appear to prove that electricity at about 2.5 cents per kilowatt-hour compares favorably with gas at $1.00 per 1000 cu. ft., and while this rate may in a general way serve for purposes of discussion, results covering a period of operation of two years in this household seem to show that the cost of current need not be reduced to so low a figure in order to compare favorably with gas for domestic operations.

TABLE SHOWING AMOUNT OF ELECTRICITY USED AND TIME WHEN USED FOR AVERAGE COOKING, BAKING, IRONING, AND MISCELLANEOUS HEATING DEVICES

Days	Breakfast 6.30-8.00	Baking 8.00-11.00	Ironing 7.00-12.00	Dinner 11.30-1.00	Misc. Day	Supper 4.30-8.00	Misc. Night	Total
Monday	¾ Kw. H.	1 Kw. H.	0 Kw. H.	1½ Kw. H.	1¼ Kw. H.	½ Kw. H.	0 Kw. H.	4 Kw. H.
Tuesday	1 Kw. H.	0 Kw. H.	2½ Kw. H.	1½ Kw. H.	½ Kw. H.	1 Kw. H.	½ Kw. H.	7 Kw. H.
Wednesday	¾ Kw. H.	3 Kw. H.	0 Kw. H.	¾ Kw. H.	0 Kw. H.	¼ Kw. H.	0 Kw. H.	5 Kw. H.
Thursday	¾ Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	¼ Kw. H.	0 Kw. H.	0 Kw. H.	2 Kw. H.
Friday	1 Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	0 Kw. H.	½ Kw. H.	½ Kw. H.	3 Kw. H.
Saturday	¾ Kw. H.	3 Kw. H.	0 Kw. H.	¾ Kw. H.	1 Kw. H.	½ Kw. H.	0 Kw. H.	6 Kw. H.
Sunday	½ Kw. H.	0 Kw. H.	0 Kw. H.	2½ Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	4 Kw. H.
Total	5½ Kw. H.	7 Kw. H.	2½ Kw. H.	9 Kw. H.	2 Kw. H.	3 Kw. H.	2 Kw. H.	31 Kw. H.
LIGHTING								
Monday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	½ Kw. H.	1½ Kw. H.
Tuesday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	¾ Kw. H.	¼ Kw. H.	1 Kw. H.
Wednesday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	½ Kw. H.	1½ Kw. H.
Thursday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	1 Kw. H.	2 Kw. H.
Friday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	¾ Kw. H.	¼ Kw. H.	1 Kw. H.
Saturday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	1 Kw. H.	½ Kw. H.	1½ Kw. H.
Sunday	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	¾ Kw. H.	¾ Kw. H.	1½ Kw. H.
Total	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	0 Kw. H.	6¼ Kw. H.	3¾ Kw. H.	10 Kw. H.

Representative of a summer month. Kw. H. means kilowatt hour.
Energy used for 4 weeks = 4 × 31 Kw. H. = 124 Kw. H. at 5 cents per Kw. H. = 5 × 124 = $6.20.

One of the two accompanying tables shows the amount of electricity used and the hours when used for the cooking, baking, ironing and miscellaneous heating devices, and the other what was used for lighting for a period of one week during winter. The records from which these tables were compiled were obtained from a carefully calibrated Bristol recording ampere meter, which is constantly kept in circuit. In view of the desirability of the heating and cooking load, being, as will be seen, largely a day load, the local electric light company made Mr. Hillman the special rate of 5 cents per kilowatt-hour, while the net price for the current used for lighting is 10 cents. While formerly the average yearly lighting bills amounted to about $30.00 to $35.00 per year, Mr. Hillman has paid the company about $110.00 per year for the past two years, since his electric kitchen has been in service.

It will be seen from the heating and cooking table that the average weekly consumption of current is about 31 kilowatt-hours, the daily use varying from 2 to 7 kilowatt-hours, the larger amount being consumed on Tuesday, when 2½ kilowatt-hours are used for ironing. It is also interesting to note that while only 4 kilowatt-hours are used on Sunday, 2½ kilowatt-hours of these were required for the preparation of the Sunday dinner. Half of the Saturday current consumption, or 3 kilowatt-hours, were used for baking during the forenoon. Using this figure of 31 kilowatt-hours as a basis, we find that the monthly consumption would be about 134 kilowatt-hours, which, at 5 cents, would amount to $6.70. This figure is checked up to an accuracy, which might be called suspicious, were not both methods of computation based on the records of accurate meters by twenty-four bills from the lighting company which are presented herewith and cover a period of two years. The average of these bills amounts to $6.62 per month and, as will be seen, the bills vary between wide limits, namely, $3.40 and $9.90.

This figure of $6.62 is about 10 to 15 per cent higher than the monthly bills were when the cooking, baking, ironing and washing was done by the coal range and gas stove. The average gas bill per month for a period of six years was about $3.50, with gas at $1.30 per thousand. The coal range was used for washing and ironing. With coal at $6.50 per ton, the average cost per month amounted to about $2.50 for less than one-half a ton. Therefore, for gas and coal together, the bills amounted to about $6.00 per month. It should be stated that no effort has been made to economize during any month for two years, except on the luminous radiator. This was the result, very largely, of an investigation which showed that during the months of October and November of the first year, the bills were as high as $8.00 and $9.00 per month, which was traced to the careless use of the radiators.

We have now arrived at that point of our story when it is customary to draw conclusions, but in view of the fact that the figures presented herewith are in themselves conclusive proof of the efficiency and practicability of this installation, there is no further need for generalization or comment.

It is essential, however, to enumerate four important factors, which should be observed, in order to insure the same success as that achieved by Mr. Hillman, and these are: Careful initial planning of circuits, judicious purchase of utensils, a five-cent or even lower rate from the central station, and the intelligent use of the utensils, so as to reduce the current consumption to a minimum.

Assured of these, the "electric home" can be operated not only as economically as a household where coal and gas have been deemed indispensable, but the highly-prized and undeniable advantages of a "wired" house over a "piped" house, namely, safety, convenience, and cleanliness, may be fully realized.

Let us hope, furthermore, and we may confidently predict, that the electric kitchen will lessen the trials and tribulations of the twentieth-century housekeeper by finally and effectually solving the servant question, considered by our helpmates one of the most stupendous and perplexing problems confronting modern civilization.

According to President Vreeland, of the New York City Railway Company, it would be more profitable to station an agent at One Hundred and Twenty-Fifth street and Eighth avenue and give each downtown passenger a nickel to travel on the elevated line rather than have him make the trip on a surface car. This simply means that the long-distance passenger would occupy a seat in the surface car which might otherwise be sold several times over to short trippers. If the passenger took an express train on the elevated line he would occupy space that could be sold but once. The haul would be quickly made and the company would then be able to use the equipment a second time.

Exports of copper from the United States in 1905 amounted to $86,225,291. This is six times the value of the copper exported in 1895.

Annual Convention of the National Electrical Contractors' Association

THE Sixth Annual Convention of the National Electrical Contractors' Association was held at the Hollenden Hotel, in Cleveland, from July 18 to 20. The convention was called to order by Secretary A. Oppenheimer in the absence of Chairman F. C. Werk of the Cleveland committee. Mayor Tom L. Johnson addressed the members, telling them among other things of his scheme to produce a car that would "shoot people from New York to Chicago in an hour, or from coast to coast in three hours." He had some doubts, however, as to whether the air friction would melt the front of the car or form icicles on it, and whether the occupants would be deviled or frappéd.

The members were also welcomed by Ward B. McAllister, president of the Cleveland Builders' Exchange, and by E. M. Lawton, of Cincinnati, who referred to Cleveland as an eating place between New York and Chicago.

In responding, James R. Strong, president of the Association, spoke of the growth and work of the Association. Its policy, he said, was to build up and improve conditions in the trade, and to stop ruinous competition. There is room for all, and each can secure and retain his share of the business with a reasonable profit.

S. C. Dickey, president of the Winona Trades School, of Indianapolis, Ind., asked for the interest of the Association in the instruction of young men in the trades. A department had been found for instruction in electrical work. At a later session a committee was appointed to cooperate with Mr. Dickey in developing this department.

"Liberty and Organization" was then discussed by Frank A. Pattison, of New York, who believed in the organization of men in the same line of business for mutual aid. Individual liberty must, however, still be preserved. He believed that the Association was improving in its membership, and that members were giving more attention to the rights of their associates and to their attitude toward customers. While limits of capital might keep some from doing the extent of work of others, yet all could do the same grade of work. The Association was of value in dealing with manufacturers and with labour unions.

On Wednesday afternoon and evening executive business sessions were held, from which non-members were excluded. On Thursday morning, J. Robert Crouse, of the Co-operative Electrical Development Association, spoke of the importance of co-operation in developing the sale of current-using devices, and outlined the work of his Association in fostering the movement for co-operation.

Speaking from the inspector's point of view, J. H. Montgomery, of the recently formed National Electrical Inspectors' Association, told of the work of the electrical inspector, and how it was of interest to the electrical contractor. Both contractor and inspector, he said, needed to study the questions from each other's viewpoint, after which they would arrive at a more satisfactory understanding.

The electrical fire hazard was discussed by C. J. H. Woodbury, of the American Telephone & Telegraph Company. He told of the formulation in 1881 of a code of wiring rules by engineers of the insurance companies meeting with Brush, Edison and other prominent electricians, which was the foundation of the present code.

The closing address of the open sessions was by J. R. Galloway, treasurer, who gave the history of the Association from its organization in Buffalo, on July 17, 1901, with 31 members, to the present with a membership of 610.

The incumbents of the various offices were re-elected as follows:—President, James R. Strong, New York; first vice-president, W. I. Gray, Minneapolis; second vice-president, Walter C. McIntyre, Philadelphia; third vice-president, F. E. Newbery, St. Louis; treasurer, John R. Galloway, Washington; secretary, W. H. Morton, Utica, N. Y.; sergeant-at-arms, J. C. Stearns, Buffalo; master of transportation, Alexander Henderson, New York. The next meeting of the Association will be at New York.

The first wireless telegraph message from the Arctic regions was that sent on July 21 by the Wellman polar expedition from Davis Island to Hammerfest, in Norway, the most northerly town in Europe. Davis Island is 650 miles north of Norway and 600 miles from the Pole.

It is reported that the Italian Government proposes to assume control of all telephone lines in Italy. The companies owning the lines will be indemnified by annual payments up to the time of the expiration of the concession.

The First Incandescent Lamp Fixtures

In telling of the pioneer days of electric lighting, G. Wilfred Pearce says, in "The Illuminating Engineer," that the first electric lighting fixtures for incandescent lamps were made by William Pearce, of Boston, to the order of George Peabody, the great banker and philanthropist. The motif was a free treatment of stalks of Indian corn and running pumpkin vines.

Twenty-six lights were set in sockets fashioned like the stems of ears of corn. The bulbs were of moulded glass made to show kernels, and the sockets had leaves of sheet brass hammered to the likeness of corn shucks. The twenty-six lights symbolized the then twenty-six States of the Federal Union. This candelabra was about twelve feet high, and was finished in ormula. The object of its manufacture was to enable George Peabody to use it in his office for the purpose of enlisting capital in floating the electrical lighting inventions of J. W. Starr, of Cincinnati, Ohio. The candelabra was afterward taken to George Peabody's banking offices in London, where Michael Faraday saw it and made it the subject of a lecture.

In his boyhood, John Pierpont Morgan saw this lighting fixture in Peabody's office, where he was apprenticed to learn the banking business, and it is known that Mr. Morgan's interests in the electrical field, which now amounts to many million dollars, was first quickened by what his father and the aged George Peabody told him in his young manhood of the brilliant young American, Starr, who was the father of the incandescent electric lamp, and who died just on the eve of making a practical dynamo.

This first incandescent electric lighting fixture was made about 1842. From the same patterns Moses Farmer, many years in the charge of the electric fire alarm system of Boston, Mass., got out material for incandescent lighting fixtures for his own home, for which he invented an incandescent lighting system dependent upon a battery. This plant was seen by Edison when he was a telegrapher in Boston many years ago.

The first public stage lighting by the electric incandescent system was brought out at Portland, Maine, in the early forties, by the inventor of mannikins mechanically moved by electricity, that went through the mimicry of the battles of Concord and Bunker Hill. For the moonlight illumination of the march of the British from Boston to Lexington, the inventor produced a fine moonlight effect from the incandescent light, and a very fine sunlight effect from a glass sun illumined by electric light, reflected from cut glass prisms.

Meyerbeer, the composer, heard of this sunlight effect at the American mannikin show, and sent over and got the right to use it for his opera "The Prophet." Dr. Colton, who brought out an electric tram car away back in 1846, and who survived to ride in modern trolley cars, said that he never saw a finer effect of electric lighting than at the mannikin show in Portland, Maine, away back in the forties.

Metallic Films for the Edison Storage Battery

A PROCESS of extreme refinement is that adopted by Thomas A. Edison in the making of the metallic films or scales used in his storage batteries, says "The Iron Age." Interest attaches not so much to the work these films perform in the battery as to the simple and beautiful method of producing them in quantity. These scales are exceedingly thin, are minute in size and each scale is curled. This form was selected for the purpose of insuring contact between the metallic particles themselves and the inclosing pockets.

The flake form possessed another advantage in that it exposed the largest possible surface to the action of the active mass. Again, the curled shape of the scale prevents the close packing of the material and maintains an open, porous condition. Crushed particles of metal would answer the purpose, but the exposed surface would then be infinitely less than with thin flakes, and the battery would be very much heavier for the capacity.

To make these films or scales in large quantities was the problem before the inventor. Upon a polished copper plate an exceedingly thin film of zinc was deposited. A film of this character is so thin that it is known among electroplaters as a "blush" of metal. The deposit is made upon the plate in a solution of zinc sulphate or other zinc salt in the usual way, the cathode thus prepared being washed and placed in an electrolytic bath, formed of an ammonium sulphate of cobalt.

Nickel can be deposited in the same way; or by combining the two solutions in the proportions of 70 per cent. of cobalt and 30 per cent. of nickel, a cobalt-nickel deposit can be produced. This deposit upon the blush of zinc is only about 2-10,000 of an inch in thickness. The plate with its two thin coatings of different metals is then immersed in dilute acid, such as sulphuric or acetic. The acid does not attack the cobalt or nickel film or the combined film of the two to any sensible degree.

The most beautiful step in the operation, and that upon which depends the final success, now takes place. The zinc is rapidly dissolved by the acid and the cobalt-nickel alloy freed from its base. But the two surfaces of the zinc are thoroughly protected from the acid—by the cobalt upon one side and the copper on the other. The edge only of the zinc comes in contact with the acid; how, then, can the two sheets be separated? The dissolution of the zinc by the acid results in the formation of hydrogen gas, which, in escaping, forces the cobalt film away from the copper plate. The alloy is detached in the form of small flakes or scales, being pushed from the copper by the hydrogen gas. It is exceedingly brittle; therefore, the scales are exceedingly small.

With most metals the flakes would be flat and useless for this purpose, since they would pack too closely and too nearly resemble a dense rather than an open mass. But it is a peculiar characteristic of both cobalt and nickel, and also of the alloy formed of the two, to become detached in curled and not in flat flakes.

It has been found possible to facilitate the stripping of the film of alloy from the zinc by coating the latter with a solution of wax or oil in alcohol. When dry, the zinc is covered with a film of wax so thin as not to prevent the proper disposition of the pure metal or the alloy of both through it.

When used in the storage battery the cobalt-nickel alloy has been found to possess advantages superior to either of those metals used alone. It has the good contact secured by the cobalt, while the nickel prevents the cobalt from more than a mere surface oxidation.

Cadiz and St. Fernando, fourteen miles apart in Southwestern Spain, are to be connected by a trolley line. Its effect in developing Cadiz will doubtless be very marked, as the population is unused to travel, the majority having seldom gone beyond the narrow neck of sand which connects the city to the mainland.

The Electrical Plant of the Canadian Niagara Power Company

By H. W. BUCK

A Paper Read at the Recent Convention of the Canadian Electrical Association

THE plant of the Canadian Niagara Power Company was the first of the power houses on the Canadian side of the falls to be designed and to have construction work begun upon it. As soon as the decision was made to go ahead with this development the question was raised as to whether the plant should be identical with those of its allied company, the Niagara Falls Power Company, on the American side, or whether engineering advances had taken place since their completion sufficient to justify changes and improvements. In general, it was decided to adopt the same system of development, but certain essential changes were introduced, as follows:—

Generating units of 10,000 H. P., instead of 5000 H. P., were adopted. The generated voltage was raised to 12,000 volts. The generators were wound for 3-phase instead of 2-phase.

When the 10,000-H. P. generators were ordered for this development they constituted the record to date for capacity, and were for a short time the "largest in the world," but, like all records in electrical work, it was of short duration. At present there are a number of machines in operation somewhat larger than these in rating, and others are being seriously considered for certain installations which will be nearly twice as large.

It was decided to change from 5000 H. P. to 10,000 H. P. for the generating units, in order to reduce the length of the wheel pit, power house, forebay, etc., and consequently to reduce their cost of construction, and to reduce the cost per H. P. of the generators, water wheels, etc.

The load of the Niagara Falls Power Company and its ally, the Canadian Niagara Power Company, had become so large that a unit of 10,000 H. P. could be installed without having such unit represent too large a proportion of the total load, from the standpoint of convenience and flexibility of operation.

The decision to have the generators wound for 12,000 volts was made to effect economies in station wiring and in the system of underground distribution necessary to transmit the power from the power house outside the limits of the Victoria Park. The particular voltage of 12,000 was selected as being the highest which at that time was considered reasonably safe for underground service, and also because the Niagara Falls Power Company had already adopted this as a transformed voltage for the transmission of power to some of its local customers.

Three-phase was taken instead of the two-phase winding of the American machines on account of the simplification of switches, wiring, etc.,

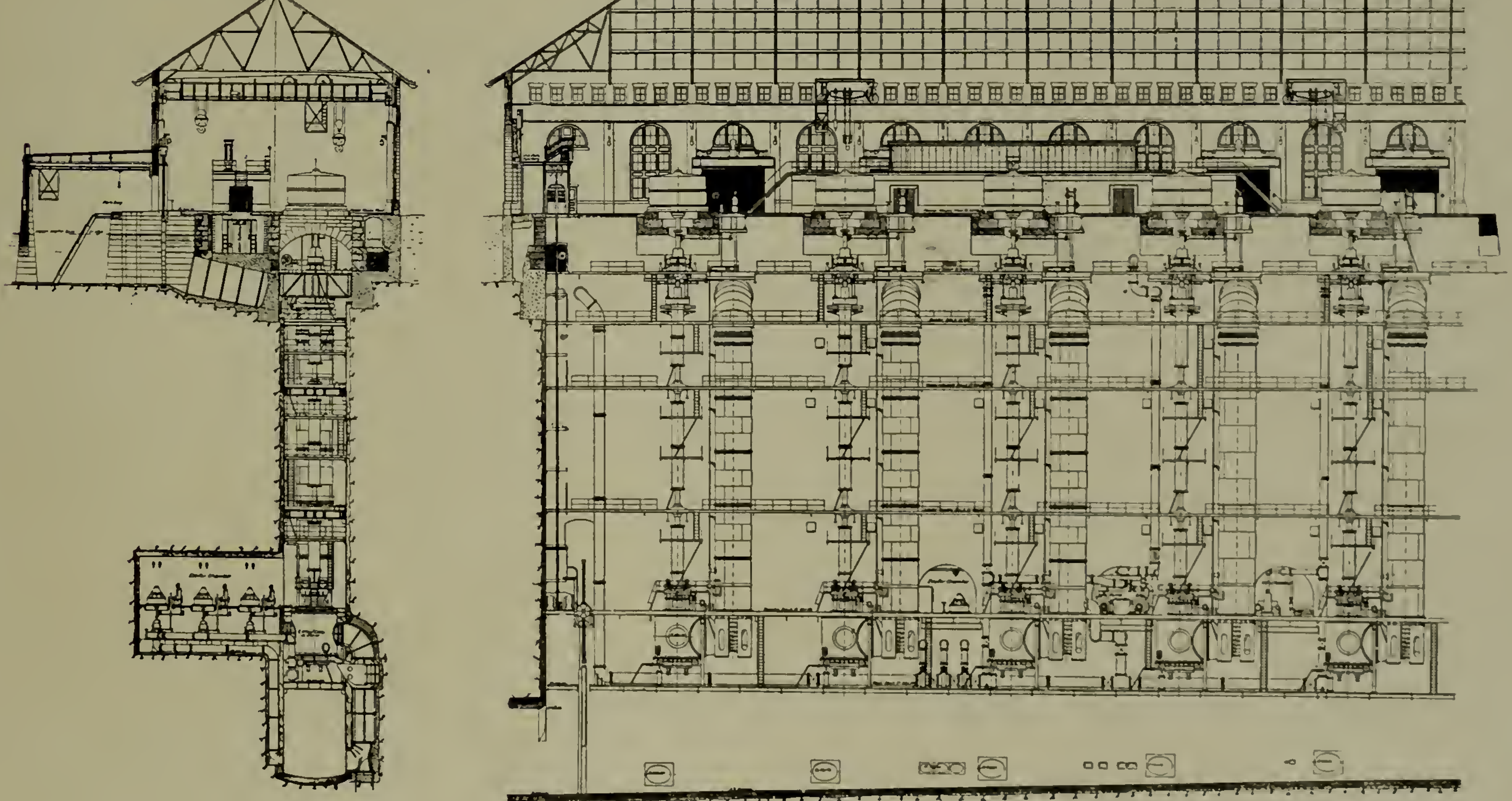


FIG. 1.—SECTIONS OF THE POWER HOUSE AND WHEEL PIT OF THE CANADIAN NIAGARA POWER COMPANY, SHOWING EQUIPMENT

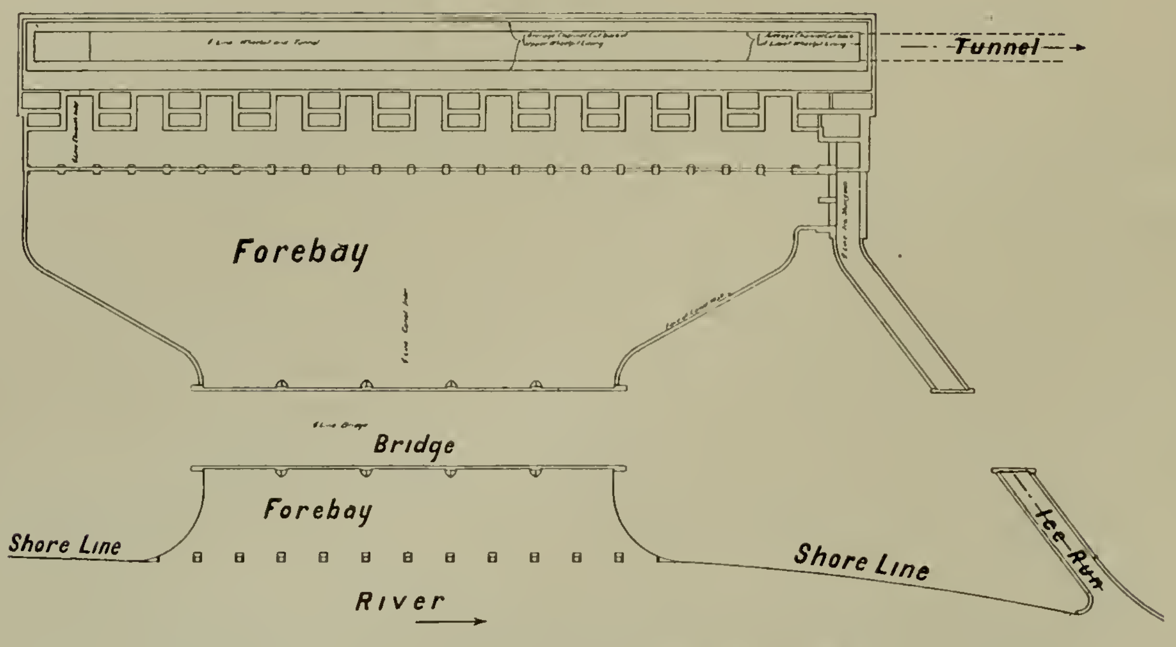


FIG. 2.—GENERAL PLAN OF THE CANADIAN NIAGARA POWER COMPANY'S DEVELOPMENT

and also to effect the saving of 25 per cent. in transmission copper.

HYDRAULIC MACHINERY

The general hydraulic construction of this plant is very similar to that of the American plant, which is too well known to engineers to require detailed description here. Fig. 2 shows a general plan of the development. Fig. 1 shows sections of the power house and wheel pit, together with their equipment.

The turbines were all designed by Escher Wyss, and the first three wheels were built at Zurich. The last two were built from the same designs by the I. P. Morris Company, of Philadelphia. The turbines are of the Francis type, inward discharge, with draft tubes led to the bottom of the wheel pit, as shown in Fig. 1.

A regulating gate is installed at the end of the wheel pit to maintain the level of the tail water at a sufficient height at all loads to cover the mouths of the draft tubes. This regulating gate is operated by an 85-H. P. direct-current motor, hand controlled. The weight of the rotating machinery is carried by an oil thrust bearing under the dynamos, and also by an hydraulic piston at the bottom of the turbine. At full-gate opening at a head of approximately 135 feet, the turbines give an output of about 12,000 H. P.

ELECTRIC GENERATORS

The generators are of the internal revolving-field type with 12 poles, giving 25 cycles at 250 revolutions per minute. The details of construction of the generator are shown in Fig. 3. The efficiency at full load is about 98 per cent., and the regulation on full non-inductive load about 8 per cent. The generators were built by the General Electric Company, a large part of the assembly work being carried out in the power house. The armatures are Y-connected, and the neutral is brought out so that it can be grounded if desired.

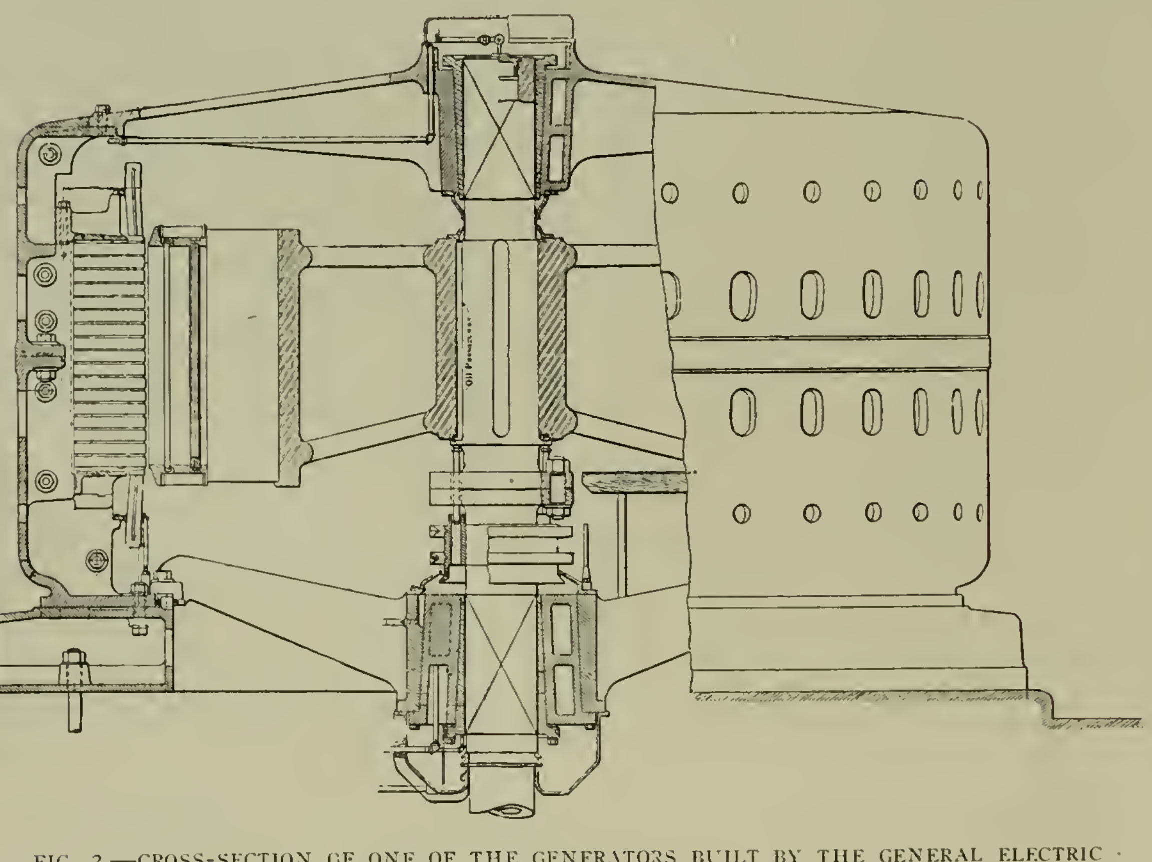


FIG. 3.—CROSS-SECTION OF ONE OF THE GENERATORS BUILT BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y.

SWITCHBOARD

From the generators the current is led through varnished cambric insulated cables to double-throw selector oil switches, and thence to the bus-bars, of which there are four sets. The oil switches are electrically operated by relay switches placed on the main switchboard panels. Fig. 5 shows a general section through the switchboard gallery, and indicates the relation between controlling panels, oil switches, bus-bars, etc.

The controlling and instrument board consists of 5 generator panels, 20 feeder panels, 10 recording wattmeter panels, and 3 bus-bar interconnecting panels. Each panel is distinct, and contains no instruments

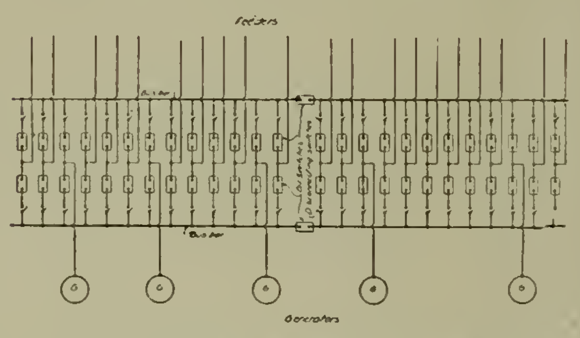


FIG. 4.—GENERAL WIRING DIAGRAM OF THE CIRCUITS CONNECTED WITH THE FIRST FIVE UNITS

or switches except those belonging to the particular feeder or generator in question. In this regard it is different from most of the switchboard arrangements adopted in modern plants.

The so-called "bench-board" system of operation usually installed economizes space, but it has certain disadvantages. The concentration of instruments and relays necessitated in this construction may cause considerable confusion at times of emergency. If instrument needles suddenly begin to slam around on their scales, it is somewhat difficult to make a prompt and correct association in a bench-board installation between the instruments and the relay switches involved, which are usually on slabs separate from the instruments. With the panel construction adopted in this plant, possibly more space is occupied by the board itself, but operating simplicity and directness results.

Each panel contains within its limits all the instruments and switches involved in any operation which the attendant has to make, and consequently there is a minimum liability to confusion and mistake. The separate panel construction also permits the separation of control wires, which become so congested in the benchboard arrangement. In case of an accident in the power house there is consequently less likelihood of a complete crippling of the control system.

The present equipment of the power house comprises five machines, and this group and its switchboard is considered as a complete plant. When the power house structure is extended to its full length, six more 10,000-H. P. units will be installed, having an entirely separate switchboard, separate exciter plant, etc. This separation is made for the reason that 50,000 H. P. is believed to be as large a block of power as should be under the control of a single switchboard and its attendant.

Fig. 4 shows the general wiring diagram of the circuits connected with the first five units.

EXCITER PLANT

The exciter plant is located in a compartment near the bottom of the wheel pit at the turbine deck level. There are three 200-KW. 125-volt d. c. generators, each connected to an independent turbine. Any two of these units will carry the entire direct-current load of the power house. There are two sets of exciter bus-bars, one of which operates the generator fields and the other the d. c. power system, including motors and arc lights. The current is carried up the pit to the main floor of the power house through a system of vertical copper bars supported every 10 feet. Fig. 8 shows the general arrangement of this plant.

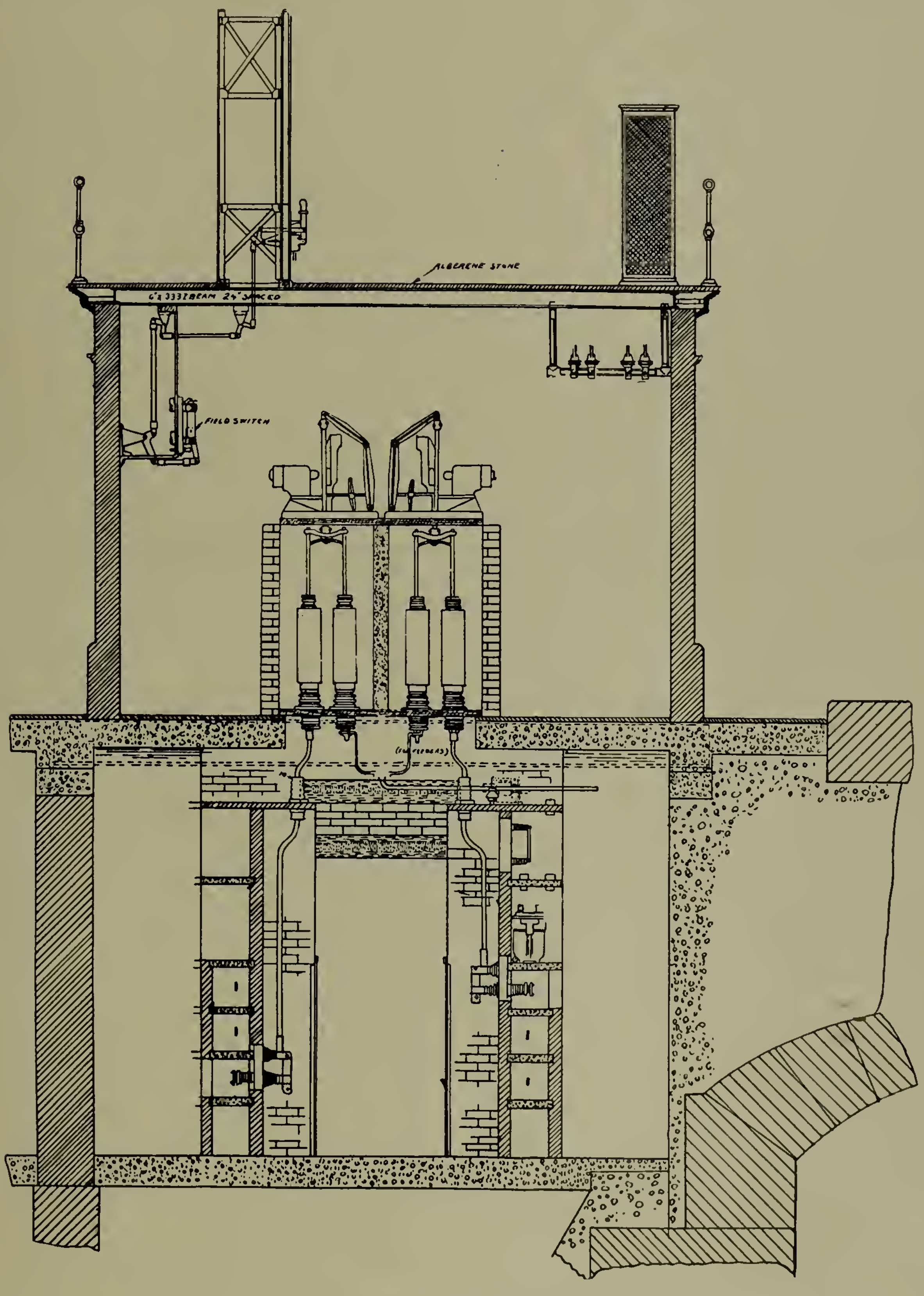


FIG. 5.—SECTION THROUGH SWITCHBOARD GALLERY

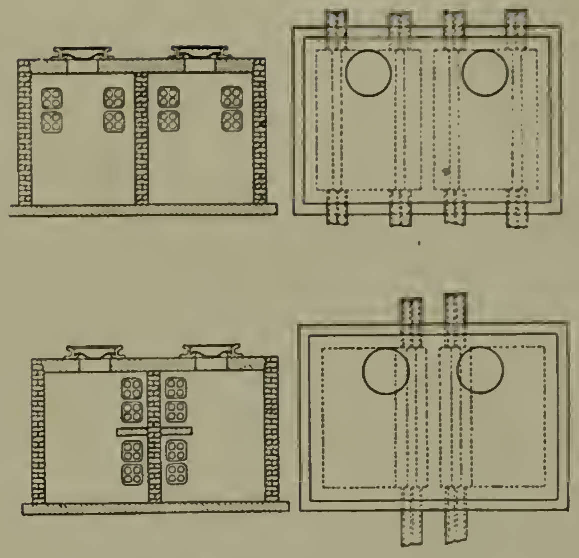


FIG. 6.—SHOWING GENERAL CONSTRUCTION OF MANHOLES AND THE GROUPING OF DUCTS

UNDERGROUND CABLE SYSTEM

All the power from the power house is transmitted underground by means of No. 000 B. & S. paper-insulated triplex lead-covered cables. The feeders are divided into two groups. One set leads from the north end of the power house through Victoria Park and across the arch bridge to the plants of the Niagara Falls Power Company, with which the feeders are interconnected. The

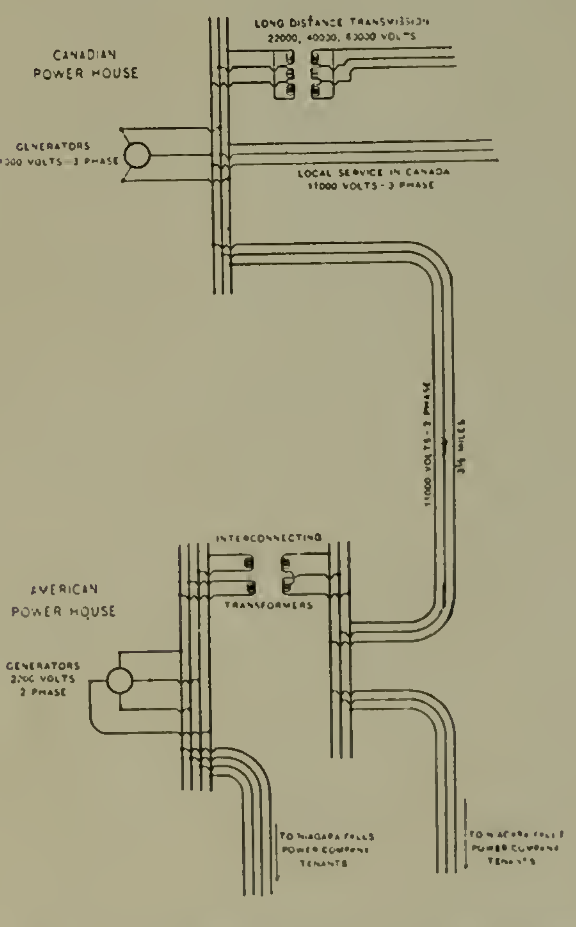


FIG. 7.—SHOWING METHOD OF CONNECTING THE THREE-PHASE, 12 000-VOLT CANADIAN SYSTEM WITH THE TWO-PHASE, 2400-VOLT SYSTEM OF THE NIAGARA FALLS POWER COMPANY THROUGH SCOTT CONNECTED TRANSFORMERS

other group runs south up the high bank above the power house to the transformer house there located.

The conduits are constructed in four groups of eight ducts each, this segregation being in order to separate the cables in the manholes, and consequently reduce to a minimum the risk of damage from short circuit and also to prevent overheating of the cables in the ducts, the separation of the groups facilitating the conduction of heat in the ground. In no case is the group wider than two ducts, so that every duct has the ground in contact at least on one face.

The cables are rated at a maximum of 4000 H. P. each at 12,000 volts. This rating corresponds to about a 40-degree C. rise in copper temperature when all the cables in the group are in service at full load. Fig. 6 shows the general construction of manholes and grouping of ducts. The manholes are all made double with a concrete fire wall between the two halves, so that in case of a destructive manhole short-circuit, not more than one-half the feeders could be involved.

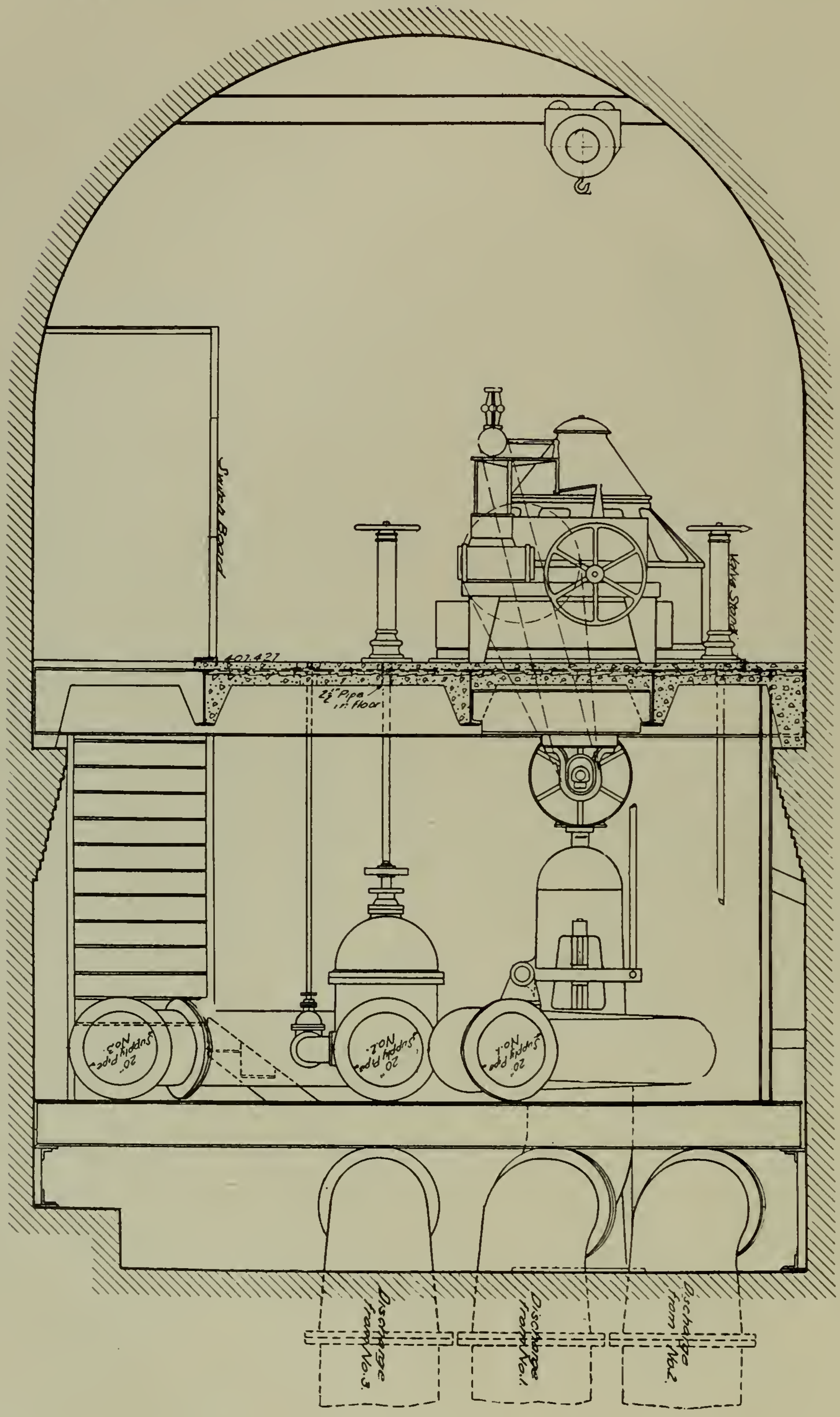


FIG. 8.—GENERAL ARRANGEMENT OF THE EXCITER PLANT

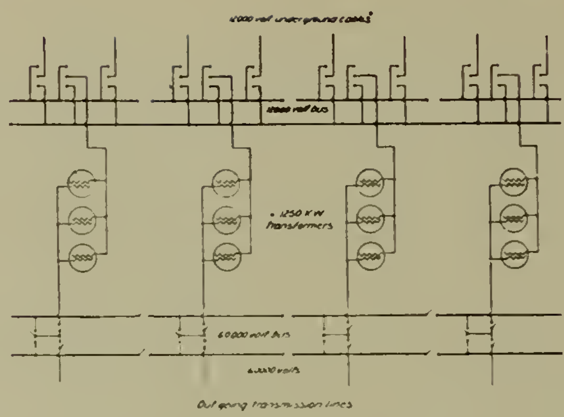


FIG. 9.—DIAGRAM OF CONNECTIONS OF TRANSFORMER HOUSE CIRCUITS

Fig. 7 shows the method of interconnecting the three-phase 12,000-volt Canadian system with the 2400-volt two-phase system of the Niagare Falls Power Company through Scott connected transformers. The two systems are constantly in operation in parallel through this connection, and no trouble is experienced from pumping or in controlling the distribution of load.

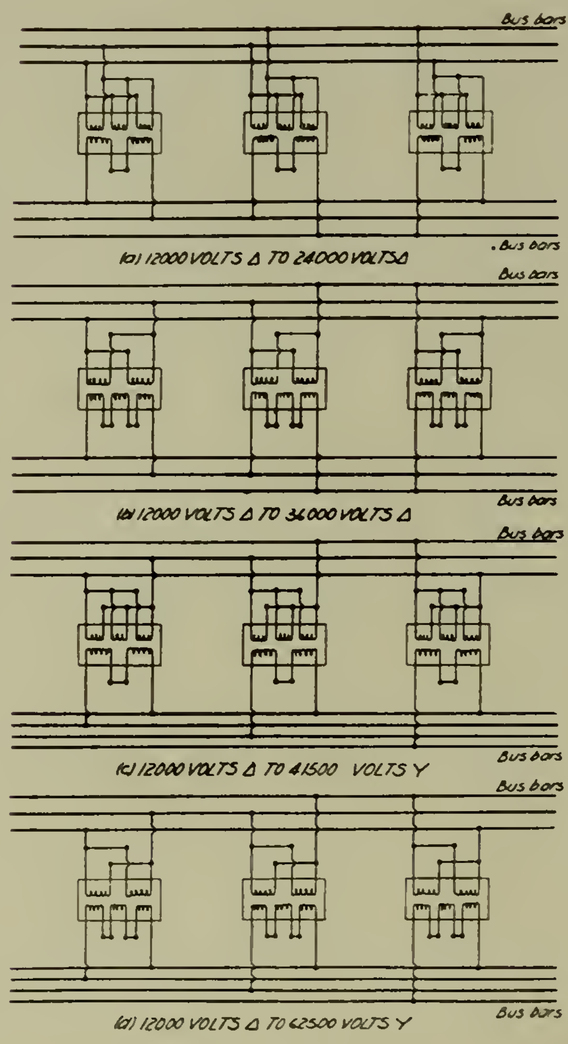


FIG. 10.—DIAGRAM OF WINDINGS OF THE 1250-KW. TRANSFORMERS

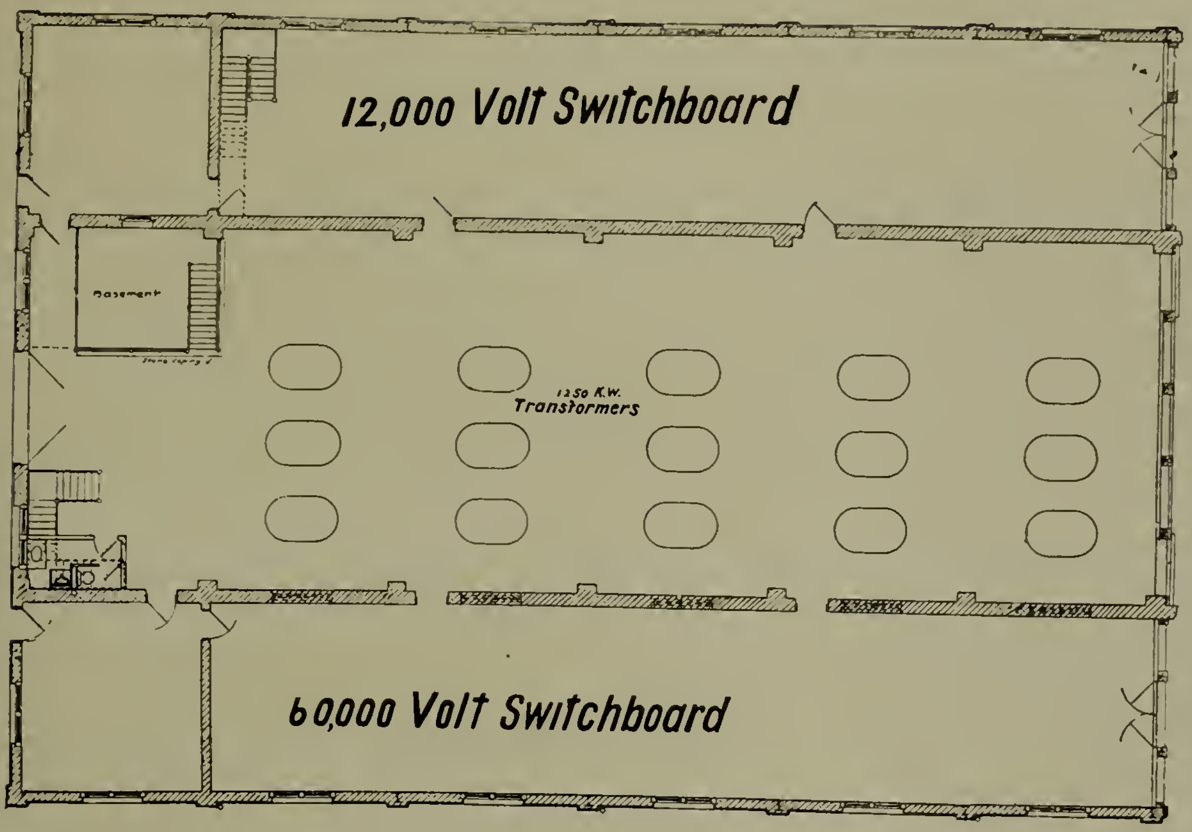


FIG. 11.—PLAN OF TRANSFORMER HOUSE, SHOWING ARRANGEMENT OF EQUIPMENT

TRANSFORMER HOUSE

Fig. 11 shows the general arrangement of the transformer house and its equipment. The installation comprises twelve 1250-KW. transformers, each bank therefore requiring one-half the output of a generator at the power house. Transformers of comparatively small size were installed for reasons of flexibility of operation. The very large transformer units now being used in some plants cost considerably less per KW., but the large size of units makes it difficult to isolate circuits and bus-bar sections so necessary at times in the operation of a plant.

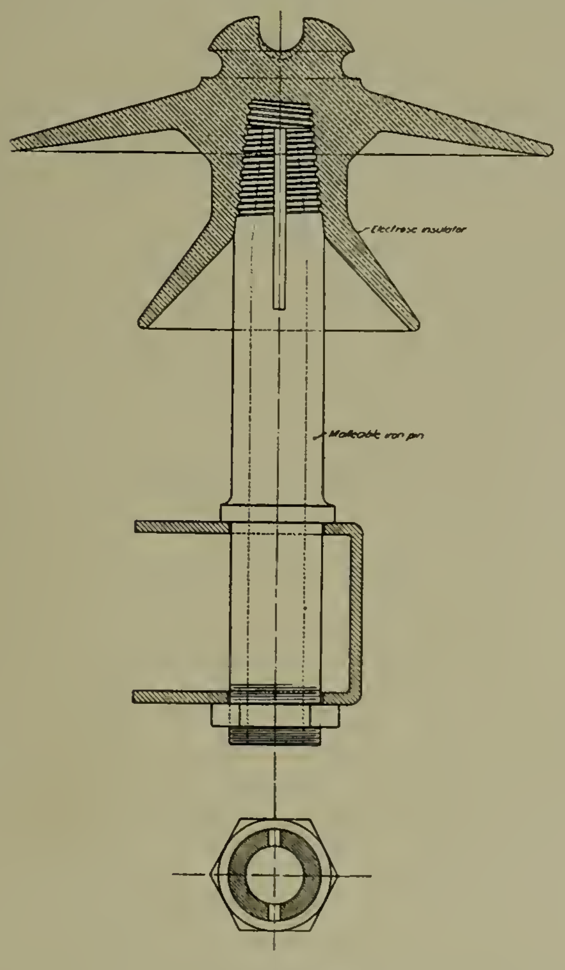


FIG. 12.—SECTION OF INSULATOR FOR THE BUFFALO TRANSMISSION LINE. MANUFACTURED BY THE ELECTROSE MANUFACTURING COMPANY, BROOKLYN, N. Y.

The building is divided into three sections. The east bay contains all the 12,000 switches and bus-bars, the central bay contains only the step-up transformers, and the west bay the 60,000-volt switching apparatus. The transformers are of the oil type, water cooled, the water supply being insured by a storage standpipe adjacent to the transformer house, with sufficient capacity to operate the transformers for 48 hours in case of a waterworks shut-down. Fig. 9 illustrates the general scheme of connections of the transformer house circuits.

The arrangement of windings on the 1250-KW. transformers are somewhat unusual. Fig. 10 illustrates the arrangement. The transformers are constructed with five similar coils, two of which constitute one winding and three the other winding, either of which can be used interchangeably as a primary or secondary. By the various combinations of coils, as shown in the sketch, any of the following voltage ratios can be obtained with the full copper efficiency of each coil:—

12,000 volts Δ to 24,000 volts Δ
12,000 volts Δ to 36,000 volts Δ
12,000 volts Δ to 41,500 volts Y
12,000 volts Δ to 62,500 volts Y

The west bay of the building also contains 3000 H. P. in air-blast transformers, which lower the generated voltage from 12,000 to 2400 for distribution of power to several small consumers in the city of Niagara Falls, Ont., to whom it would be unsuitable to deliver power at as high a voltage as 12,000 volts. This distribution at 2400 volts is by an overhead line.

All the high-tension wiring in the transformer house is insulated for the highest voltage, 62,500 volts, and the conductors are of sufficient current-carrying capacity for operation at full output at the lowest transformer voltage, 24,000 volts.

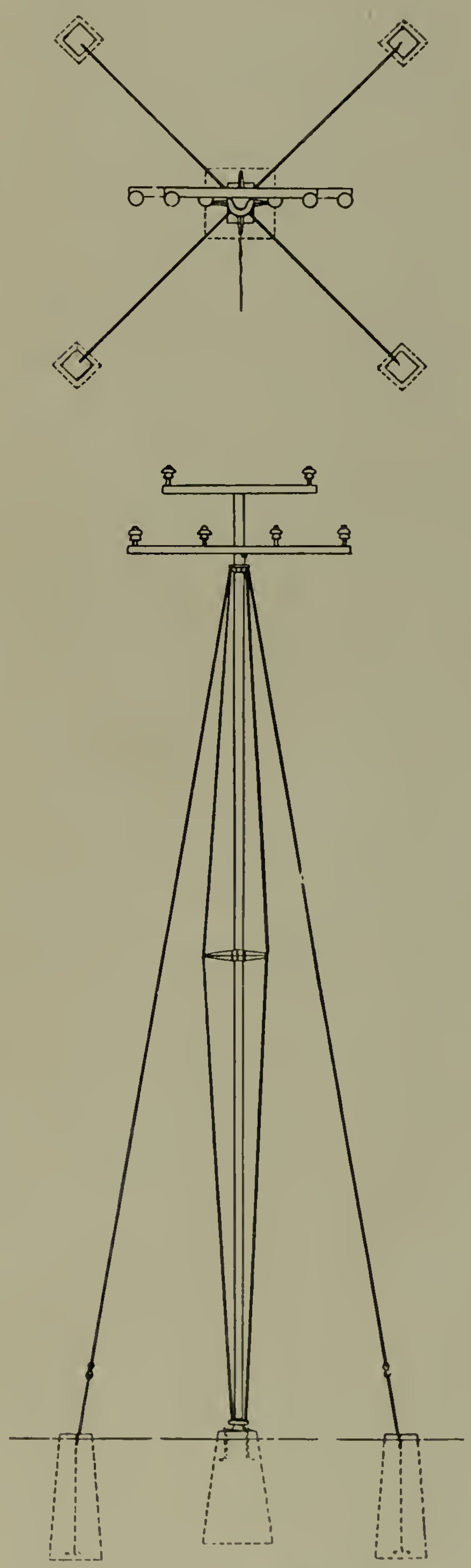


FIG. 13.—POLE FOR THE BUFFALO TRANSMISSION LINE

BUFFALO TRANSMISSION LINE

The output from this transformer house will be used partially for transmission at 24,000 volts to Fort Erie, channels of special section; and the pins are malleable castings secured through the cross-arms by nuts on the bottom.

FIG. 41.—MAP SHOWING RIGHT OF WAY OF THE BUFFALO TRANSMISSION LINE

and thence across the Niagara River to Buffalo, the distance being about 15 miles. There are some engineering features connected with this work which may be of interest.

The transmission line is built on a private right of way 30 feet wide extending from the transformer house to the River front at Fort Erie. There will be two pole lines on this right of way, each carrying two circuits. The circuits have a nominal rating of 12,500 H. P. each at 24,000 volts, making 50,000 H. P. total for the transmission.

The poles used are shown in Fig. 13, and consist of two 4-inch wrought iron pipes, jointed together at the center, as shown, by a casting which has four struts projecting radially at 90-degree angles. Truss rods secured at the top and bottom of the poles pass over the ends of these struts, which, when tightened up, stiffen the jointed pipe. The function of this central tubular member is to resist downward compression only.

The horizontal stresses on the pole are resisted by four guy rods anchored in the ground with concrete guy stubs. There is one of these guys in each quadrant around the pole. Under the central member of the pole is placed a heavy block of concrete which carries the iron step for the central pipe and takes the thrust. All the castings are malleable. The cross-arms are made of

This type of pole is very strong and very economical in iron. The central member is under direct compression only, and the guys are under direct tension, which stresses require the minimum amount of material to resist. There are no lapped joints to rust out, and the sections are all large enough to withstand considerable corrosion without weakening. The poles are 40 feet in height, and are placed apart at distances ranging from 250 to 300 feet. Fig. 14 shows a map of the transmission line right of way.

The insulators shown in Fig. 12 are made of a compound known as "electrose." This material is a very good insulator, is very strong mechanically, and is entirely free from cracks and other defects which are common in glass and porcelain. Similar insulators have been used on the Buffalo transmission lines of the Niagara Falls Power Company for the past three years, and they are the only insulators on those lines which have caused no trouble. It is impossible to shatter electrose insulators by stone throwing, and they will frequently turn a rifle bullet without being damaged seriously. The conductor used on this line is of aluminum, 500,000 cir. mils in section and having 37 strands.

At Fort Erie the line is tapped by a connection to a local sub-station for the supply of power to that muni-

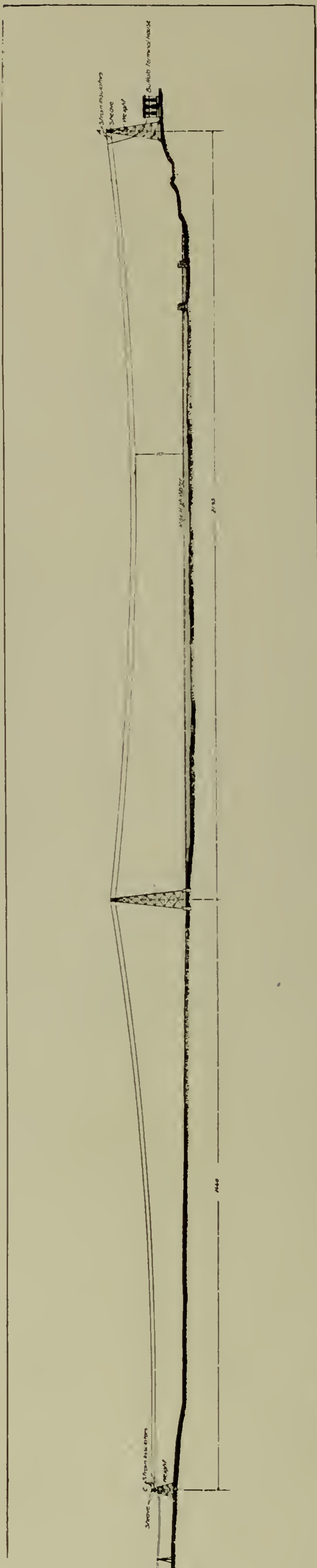


FIG. 15.—THE LONG SPAN OVER THE NIAGARA RIVER, 1200 FEET TO THE FIRST TOWER AND FROM THAT 2300 FEET TO THE BUFFALO SHORE

cipality. The line then rises from the standard 40-foot elevation to a tower 80 feet high, erected about 1200 feet from the Canadian shore line of the Niagara River. Thence the line rises again by a single span of 1200 feet to a tower on the river bank 210 feet in height. Thence by another single span of 2300 feet the line passes to the Buffalo side of the river to another 210-foot tower. From there it drops down to a new 50,000-H. P. terminal house constructed for the distribution of this power in Buffalo.

Fig. 15 shows the general profile of this long span crossing; 500,000-c. m. 61-strand aluminum cable is used. Each wire is secured to the top of pole *B* on an insulated support. At towers *A* and *C* the lines are attached through strain insulators to steel cables, which pass over sheaves about 24 inches in diameter, and thence to weights which are equal to the tension on the wire in pounds, amounting to 4500 pounds on each line. The live portion of the line passes down the tower from the outside of the strain insulator to the terminal house on the Buffalo side and to the main transmission line on the Canadian side.

The object of this arrangement is to obtain a maximum clearance above the water with a minimum height of tower. By keeping the span under constant tension the deflection becomes independent of variations in temperature and also independent of wind stress allowance. In a fixed span of this length the increase in deflection in summer, due to the heat of the sun, would amount to at least 40 feet. With the weight and sheave arrangement the deflection is maintained constant at the minimum. At times of heavy wind stress the weights will rise and prevent the tension in the cable from ever exceeding the predetermined amount equal to the balance weight.

The power house has been in successful operation for about a year, and five generators are now in service. The transmission lines to Fort Erie and Buffalo are now in process of construction, and are expected to be placed in service about the first of November.

Incandescent Lamp Renewals

By J. W. COWLES

EVERY public service corporation may rightly include among its most essential assets the good-will and satisfaction of its customers. To the central station manager the question of how far he can extend conveniences and privileges to his customers, without actual injustice to his company, is one requiring constant thought and study.

Probably the question of incandescent lamps affords as much ground for discussion as any one of the various details of the distribution system, and while the solution of the problem must, to some extent, depend upon local conditions, the experiences of different companies are always interesting. The question of liberal supply of lamps for both initial installation and subsequent renewals seems almost beyond argument, though not yet universally adopted.

To the average layman, to whom a lamp is a lamp, the opportunity to buy lamps in the vicinity of ten cents apiece is very attractive, in comparison with others at double the price, and an examination of lamps brought in from the premises of customers to whom free lamp supply has been unknown, will show very strikingly how little regard has been given to quality and cost of operation in the purchasing of lamps. Assuming that all billing is on a meter basis, the careful selection of lamps with reference to wattage is of greatest importance, since the customer's satisfaction may safely be assumed to hinge largely upon the reasonableness of his bills, and unfortunately his own purchasing of lamps is rarely done with full regard to economical operation.

With the assurance of each customer fully supplied with proper lamps at the start, the question then arises as to the best method of keeping him supplied with fresh lamps for the renewing of burned out and dim ones. The practice of depending upon the customer to send his old lamps in for renewal has invariably proved unsatisfactory to both parties, and results in lamps being burned far beyond their economical life, and the customer finding himself without fresh lamps perhaps at the time when most needed.

Some sort of delivery system to the customer must be maintained, and while with the small company a method of delivery upon request may suffice, in any large system a regular routine delivery must be maintained, with constant urging upon the customer to make full use of the opportunity for obtaining fresh lamps for his old ones whether burned out or noticeably dimmed.

Owing to the various candle-powers and styles of lamps which it is necessary to carry, such a delivery can practically be carried on only by team, and in the case of one company four teams working continuously are obliged to average ninety to one hundred calls a day in order to visit each customer once in six weeks. By delivering lamps directly to the premises of the customer and receiving the old lamps directly from his hands, the chances of imposition are greatly reduced, as the likelihood of lamps furnished being improperly used, and of all lamps being turned in for new ones in exchange by parties not customers, is much less than where lamps are brought to the station and exchanges are made unsystematically.

In the various candle-powers and styles of lamps, frosted and coloured (dipped) may be safely included in 8 candle-power and over, the 4 and 2 candle-power preferably being furnished only for signs. In the special lamps, such as the tubular, spherical, "Hylo," and the like, good results may be obtained by furnishing them with an excess charge equal to the difference between the cost of the regular lamp which the company is ready to furnish and the special type which the customer desires.

While liberality in the supply of lamps can hardly be urged too strongly, it is none the less important that the customer should be held responsible for all lamps furnished him, paying for those which may, through carelessness or accident, be lost, and for all shortage which may be found at final discontinuance.

For the success of a periodic delivery system some means should be employed for informing each customer of the dates on which the "lamp exchange" team will call, in order that lamps may be in readiness for exchange at the time of call, since it is obvious that it will be impossible for the agent to wait for lamps to be collected about the premises. With the territory sufficiently divided into districts, a schedule of dates can be made up for months and even a year in advance and furnished to each incandescent customer.

A method of still higher efficiency

is to notify each customer by postal card two or three days in advance of each delivery of the exact date that call will be made upon him. In practice, however, this bethod has not proved itself of sufficiently greater value to warrant the very considerable increase in clerical and mailing cost.

By the system above described, the cost of lamp renewals is necessarily increased somewhat over a "hit or miss" method, but a still greater proportionate increase may confidently be looked for in monthly earnings. With the rapid introduction of incandescent lamps of higher efficiency, the heretofore common method of figuring the cost of lamp renewals on the kilowatt-hour basis must be abandoned somewhat, since with lamps of higher cost and consuming less energy, the renewal cost per kilowatt-hour must of necessity increase. This item, still an important expense factor, should not be given the importance it has formerly received.

While the treatment of this question by each illuminating company must of necessity be governed somewhat by local conditions, the working out of such methods as above described has been found a most interesting and profitable one in connection with the various other problems of the distribution system.

Electropneumatically Actuated Organs

THERE are perhaps few, if any, uses of electromagnetism in the arts, says "Cassier's Magazine," that in ingenuity of design and reliability of operation approach its application to modern electropneumatically actuated organs. The motive power for the bellows or blowers that suppply the air pressure in all up-to-date organs is furnished by electric motors which lend themselves admirably to the rapidly varying minimum to maximum demands made upon them.

The keys of the clavier, or keyboard, and the pedal keys are connected with electrical contacts which, in turn, are connected with wires leading to small electromagnets at the foot of the organ pipes. The armatures of the magnets are about the size of a 5-cent piece, and act as valves which admit the necessary amount of air pressure. The magnets are about 2 inches long and are wound with No. 22 B. & S. copper wire.

For the key contacts, some manufacturers use gold and platinum, while others employ silver. None of these wires oxidizes, but silver is the cheapest. The contacts are self-cleaning or rubbing contacts, and are so constructed and protected mechanically that a uniform contact is made regardless of the violence with which the manual or pedal keys may be operated. The wires leading from the contacts to the organ proper are carried in a cable.

It is obvious that the console may be any reasonable distance from the organ; also, that duplicate consoles may be placed in different places in a large auditorium. It would also be feasible to so arrange the circuits that one organist could play two or more organs in different places simultaneously from the one console.

Rare Earth Auxiliary Conductors for Arc Lamps

THE excellent light efficiency attained in flame arc lamps, Nernst lamps and incandescent gas mantels is due, as is well known, to the presence in them of mixtures of the rare earth oxides, a characteristic property of most of which is the fact that they only become electrical conductors when heated. One of the earliest lamps in which the advantageous effect of such light-giving substances was noticed was the Jablochkoff candle (1876), in which the good light obtained was chiefly due to the presence of the rare earths in the substance used to separate the two carbons. The well-known Soleil lamp (1879) worked on a somewhat similar principle. These lamps have ceased to exist chiefly because of their short burning period, and the difficulty of starting the arc in them.

An attempt to combine the advantages of these early lamps with those of the modern arc lamp, according to E. Stadelmann, in "Elektrotechnische Zeitschrift," points to the use of the rare earth mixture only as an auxiliary to the ordinary arc after the latter has been started. Thus a block of the material might be placed close to and above, but not in contact with the carbons of, a horizontal arc, so that when the arc had been started in the ordinary way, it would heat up the mixture and cause this to carry a certain amount of the current of the circuit, and so give out light in the same way as the filament of the Nernst lamp does.

The advantages of such a combination are three-fold:—Improved light efficiency; good reflection of the light of the arc in a downward direction; and improved steadiness of the light owing to the light-accumulating property of the rare earth mixture. The effect of this last action has been found to be very marked. The composition of the mixture is, of course, of the first importance, as, besides having the required electrical properties, it should be capable of withstanding the very high temperature with little or no vaporization, so that frequent renewal is not necessary.

Experiments have shown that one suitable substance is chamotte, which, though it becomes soft under the action of the arc, does not drop off. Further investigation in this direction may, however, lead to the discovery of some still more suitable substance.

The Bonn-Cologne High-Tension Direct-Current Railway

SOME interesting details of the high-tension direct-current railway between Bonn and Cologne in Germany, are given in a recent number of "L'Eclairage Electrique." The length of the line is 17 miles, a voltage of 550 being used in towns, and 990 outside.

The conductors are run overhead and are double, connected by crosspieces to which are fixed the connection for the catenary suspensions. The poles supporting the wires are 155 feet apart on the straight and closer on curves. The return is effected by the rails, which are bonded every 110 yards. Signal and telephone wires are laid in cable underground.

The line is divided into three sections for feeding. The Marienbourg to Surth section is fed at Surth by a feeder assisted by a battery of 330 ampere-hours capacity. There is also a booster capable of raising the voltage of the feed current by 150 volts. The second section, from Surth to Hersel, is fed from the generating station direct; and the third, from Hersel to Bonn, is fed in at Hersel, where is also a battery and a booster.

Two sets of 350-KW. each, direct driven by compound tandem engines, are installed in the power station. There are also two boosters for feeders, and a Pirani booster for charging the battery. The action of this booster is such that when the demand for current is large, it boosts discharge current from the battery; when there is a surplus, the booster raises the voltage of the line current to charge the battery.

The Westinghouse single-phase system is to be used on a suburban line near Stockholm, Sweden.

The Economics of Electric Transmission

By H. B. GEAR, of the Chicago Edison Company

THE economic phases of electric transmission systems have been the subject of discussion by various authors from the date of the first enunciation of the now classic "law of Kelvin" to the present time. The usual method of treatment of the subject has been along general lines, which have been only illustrative of the principle and not directly applicable to any specific problem.

The purpose of the present article will be to illustrate the method pursued in adapting the general principles of the law of Kelvin to the problems incident to the transmission of electrical energy in a large distributing system.

The engineer in charge of the design of a large distributing system is confronted with the problem of transmitting considerable amounts of energy from point to point over feeders at various voltages, by means of two-wire, three-wire or four-wire lines and by overhead and underground lines. The selection of the proper size of wire or cable affects investment, operating and dividend accounts, and is, therefore, essentially an economic problem.

The annual cost of maintaining and operating a feeder is composed of two parts which are so related to each other that as either is increased, the other decreases. These elements are:—(a) Fixed charges (interest and depreciation) on the investment. (b) The value of the energy lost on the feeder during a year's operation.

The investment includes the cost of the feeder conductors, and of the station capacity required to carry the load due to the loss on the feeder at the time of its annual maximum load. The portion of the investment due to value of station capacity is a larger factor in the problem than might at first appear.

The fixed charges, interest and depreciation on the investment must be figured from the current rates of interest on borrowed capital and from an assumed rate of depreciation based on past experience and future possibilities. The methods of estimating depreciation are various, the rates taken varying from 2 per cent. in the case of some municipal undertakings, to 10 per cent. in cases where plants have been rebuilt frequently and the depreciation due to the growth of the art has been very high.

Generating stations driven by water power are on a more stable basis than those operating by steam, as the steam station is still capable of great improvements. It is, therefore, considered by managers of large properties that it is not too conservative to estimate the probable life of steam station apparatus at fourteen years, or 7 per cent. a year. The depreciation of buildings of good construction should not be over 3 or 4 per cent. The combined rates of depreciation on a generating plant, including building and apparatus, may be fairly assumed at 5 per cent. The usual rate of interest on capital invested in electrical properties is 5 per cent., and the fixed charges on generating equipment may, therefore, be conservatively estimated at 10 per cent.

The depreciation on feeder conductors is more rapid than that on generating apparatus, but the junk value is a much larger proportion of the original cost than is the case with station apparatus. Weather-proof wire consists of about 80 per cent. copper and 20 per cent. insulation in the sizes ordinarily used for feeders. There is no depreciation on the copper, except the labour of replacing it about once in ten or twelve years when the insulation is worn out. The increase in the value of copper as years go by is likely to offset the loss on the insulation, so that at best it is an uncertain quantity. It will be conservative, however, to figure 10 per cent. on the 20 per cent. of insulation, or 2 per cent., and 1 per cent. for the labour of replacing, making a total of 3 per cent. of the original cost of the wire.

The life of lead-sheathed paper or rubber cables is yet indeterminate, but there is good reason to hope that these may be serviceable for at least fifteen years. The junk value is comparatively high, as the copper is from 30 to 40 per cent. of the original cost, and the lead sheath constitutes a considerable percentage of the cross-section of the cable. It will, therefore, be fair to estimate the depreciation on lead-sheathed cables at 4 per cent.

In a growing system the replacement of feeders due to the expansion of the load carried, results in more rapid depreciation than is experienced in a system where the feeder conductors remain undisturbed until they are too far gone to be of further service.

The value of the energy loss on a feeder varies with the size of the conductor, the "load factor," and cost of generating a kilowatt-hour at the switchboard.

For the purpose of illustration, let us assume a set of conditions similar to these found in a medium-sized distributing system. A two-wire overhead feeder, 1000 feet in length, consisting of weather-proof wire costing 20 cents a pound, is supplied by current from a generating plant costing $150 per kilowatt of capacity installed. The interest is to be reckoned at 5 per cent. The depreciation on the line is 3 per cent. and on station capacity 5 per cent. The cost of energy at the station switchboard is to be taken at 1 cent per kilowatt-hour, and the shape of the load curve is such that the annual "load factor" is about 30 per cent.

The three components of the total annual cost of operating this feeder, namely, the fixed charges on line wire, fixed charges on station capacity, and value of energy loss, may be designated, for convenience, as A, B and C, respectively. Each of these quantities may be expressed in algebraic form, by an equation containing one variable, the resistance of the feeder. These equations are derived as follows:—

The fixed charges on line wire, designated A, are to be taken as 8 per cent. of the value of the line copper, the cost of the pole line being neglected, as it is practically independent of the size of wire. The value of a feeder 1000 feet long is the value of 2000 feet of wire at 20 cents per pound. It will be found, upon consulting a table of weights of the various sizes of wire from No. 2 to 4/0, that there is nearly constant relation between the weight and resistance per 1000 feet of each of these sizes. This may be expressed in the equation $W R = 39$. The weight of 1000 feet of two-wire feeders is, therefore,

$$W = \frac{2 \times 39}{R}$$

and its value at 20 cents a pound $=$

$$\frac{2 \times 39 \times .2}{R} = \frac{15.6}{R} \text{ dollars,}$$

in which R is the resistance of 1000 feet of conductor.

The fixed charges at 8 per cent. are, therefore,

$$\frac{.08 \times 15.6}{R} \text{ or } A = \frac{1.248}{R} \qquad (1)$$

The investment in generating capacity required to supply the feeder loss at its annual maximum load is equal to the product of the loss at

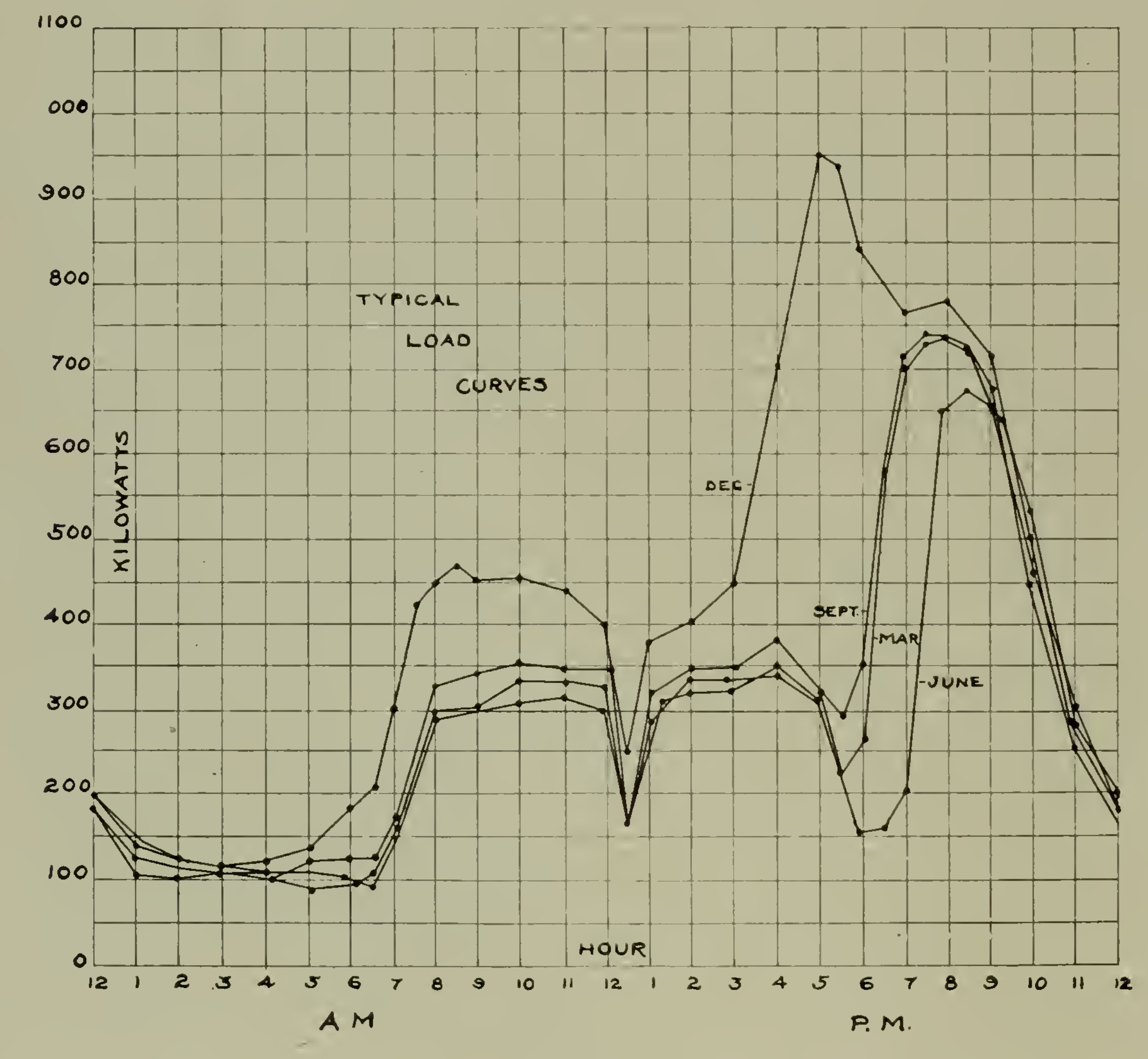


FIG. 1

maximum load by $150, the value of a kilowatt of generating capacity. The loss in kilowatts at the maximum load is $\frac{2C^2 R}{1000}$, in which C equals the current at maximum load and R equals resistance of 1000 feet of conductor. The investment in station capacity is, therefore,

$$\frac{2 C^2 R \times 150}{1000} = .3 \; C^2 R \text{ dollars.}$$

With fixed charges at 10 per cent., the annual expense due to these charges on generating capacity is:—

$$B = .1 \times .3 \, C^2 R = .03 \, C^2 R \qquad (2)$$

The value of the energy dissipated on the feeder is known from the generating cost and the annual loss in kilowatt-hours. The calculation of this loss is usually a rather tedious process, which need not be detailed here in full. However, some discussion will be necessary for the sake of the illustration which we are carrying through.

In Fig. 1 are shown load curves from a working system. The four curves show the variation of load from hour to hour on representative week days in March, June, September and December, respectively. The annual "load factor" of these curves is about 32 per cent.

Inasmuch as the energy loss varies with the square of the current, it must be calculated for each hour of the day, the loss for representative days in the year being used as a basis of calculation of the annual loss, allowance being made for holidays and Sundays. This having been done, it will be found that the "load factor" of the feeder loss is less than that of the load carried by the feeder. In the curves of Fig. 1 the load factor of the feeder loss is 13.4 per cent.; that is, the annual loss is equivalent to what the loss would be if the feeder carried its maximum load continuously 13.4 per cent. of the year. The loss at maximum load being $\frac{2 C^2 R,}{1000}$ the annual loss on any feeder carrying a load similar to that of Fig. 1 is the product of the maximum load loss by 13.4 per cent. of the hours in a year, or 1162. The annual loss in kilowatt-hours is, therefore:—

$$\frac{2 C^2 R \times 1162}{1000} = 2.36 \; C^2 R$$

The value of the annual loss at 1 cent per kilowatt-hour is, therefore:—

$$C = .0236 \, C^2 R$$

The total annual cost is, therefore:—

$$A + B + C = \frac{1.248}{R} + .03 \, C^2 R + .0236 \, C^2 R = \frac{1.248 + .0536 \, C^2 R^2}{R}$$

The problem being to find the most economical value of R for a given current, the equation may be treated according to the usual method of calculus with R as a variable.

That is, if $y = \frac{1.248 + .0536 \, C^2 R^2}{R}$

$$\frac{d y}{d R} = \frac{.0536 \, C^2 R^2 - 1.248}{R^2}$$

The value of y being a minimum when $\frac{d y}{d R} = 0$, it follows when $\frac{d y}{d R} = 0$, that $.0536 \; C^2 R^2 - 1.248 = 0$,

$$\text{and } \; C^2 R^2 = \frac{1.248}{.0536} = 23.3$$

$$\text{whence } C R = \sqrt{23.3} = 4.83,$$

$$\text{or } R = \frac{4.83}{C}$$

Substituting any desired value of C, the maximum current, the value of R is readily found. By comparison with a wire table containing the resistance per 1000 feet of the various sizes of wire, the most economical size of wire for the above asumed conditions is known.

This equation also means that under the conditions above assumed, the ohmic drop at the maximum load of the year should be $2 \times 4.83 = 9.66$ volts per 1000 feet of feeder, when the most economical size of conductor is employed. That is, on a 2000-volt feeder 10,000 feet long, the drop should be 96 volts, or about 5 per cent. If the maximum current on this feeder were 60 amperes, R would be $\frac{4.83}{60} = .0805$ ohm. The resistance per 1000 feet of No. 00

wire is .078, and this would, therefore, be the most economical size to use.

On a 220-volt, two-wire feeder 2000 feet long, the drop should be 19.3 volts, or about 9 per cent. With a maximum current of 200 amperes the resistance should be $\frac{4.83}{200} = .0241$ ohm, which is approximately the resistance of 400,000-cir.-mil cables. In general, under the assumed conditions, the cross-section should be about 2000 cir. mils per ampere.

With copper at a lower price, with different rates of computing fixed charges, investment and energy cost, it is obvious that the above result would be modified. The interpolation of other values is, however, easily accomplished, and the problem is, therefore, easily solved for any other set of conditions.

The rate of variation of the three quantities, A, B and C, which compose the annual cost, is illustrated in the curves of Fig. 2, which are calculated for a maximum load of 60 amperes.

It will be noted that the minimum point on the total cost curve is at No. 00 wire, as above calculated. It will also be noted that the curve of total cost is rather flat in the region of the mimimum, and that the use of a size smaller or larger than No. 00 would affect the annual cost less than 5 per cent. This is of importance in a growing system, as it permits of the operation of feeders temporarily at higher or lower loads than their most economical ones without seriously affecting the economy of operation.

The equations above deduced are applicable only to two-wire feeders. It is, therefore, of importance that similar equations be derived for three-wire Edison, three-phase, three-wire, and three-phase four-wire feeders.

Making the same assumptions as to cost of generating equipment, energy, etc., that were made in the case of the two-wire feeders, the fixed charges on the line investment for a three-wire Edison feeder will be 1.5 times those for a two-wire feeder, when the third wire is the same size as the others.

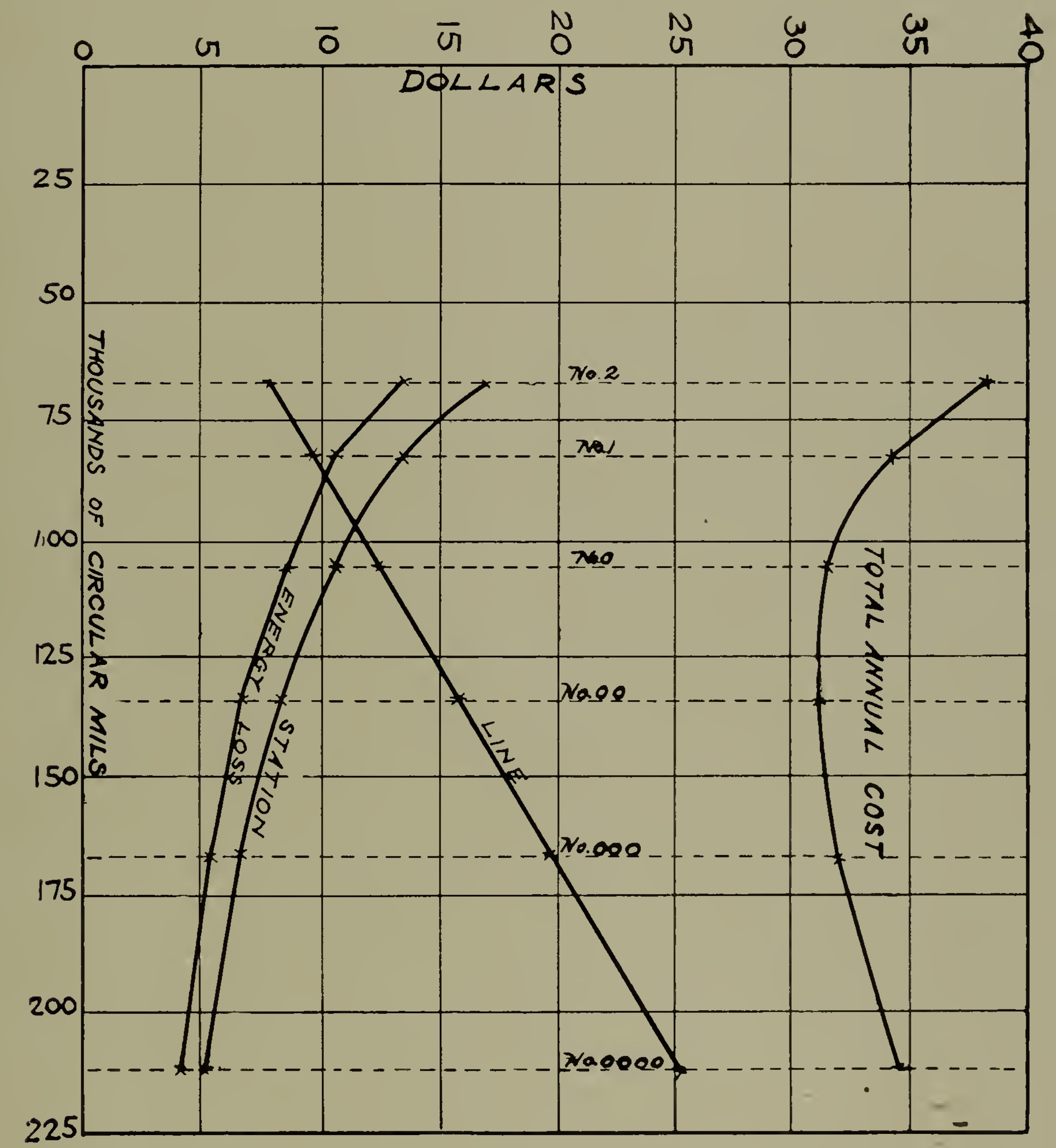


FIG. 2

Hence, fixed charges are

$$A = \frac{1.248 \times 1.5}{R} = \frac{1.872}{R}$$

The fixed charges on generating capacity and the value of the energy lost is the same as in the case of the two-wire feeder.

The total annual cost is, therefore:—

$$A + B + C = \frac{1.872}{R} + .0536\, C^2 R$$

This will be a minimum when

$$C^2 R^2 = \frac{1.872}{.0536} = 35$$

and $C R = 5.92$.

In the case of a three-wire, three-phase feeder, all the elements are increased 50 per cent. over the figures for the two-wire feeder, since the current in each wire is the same.

$$\text{Hence, } A + B + C = \frac{1.872}{.0814} = 23$$

and $C R = 4.83$, which is the same as in the case of a two-wire feeder.

In the case of a four-wire, three-phase feeder, the fixed charges on the line are twice those of the two-wire feeder. The other elements are 1.5 times those of the two-wire feeder, with balanced load.

$$\text{Hence, } A + B + C = \frac{2.49}{R} + .0814\, C^2 R.$$

This is a maximum when

$$C^2 R^2 = \frac{2.49}{.0814} = 30.6$$

and $C R = 5.53$.

The above calculations have all been based on steam power. In case the power is hydraulically derived, the value of the energy lost on the feeder is a negligible quantity, and the annual cost for a three-wire, three-phase feeder, for instance, becomes—

$$A + B = \frac{1.872}{R} + .03\, C^2 R$$

This is a minimum when

$$C^2 R^2 = \frac{1.872}{0.03} = 62.4$$

and $C R = 7.9$.

The use of weatherproof insulation was also assumed in the foregoing. If bare wire were used, the fixed charges on line investment would be reduced, since $W R = 32$ for bare wire, and the depreciation would be negligible. The fixed charges on the line would be for a two-wire feeder

$$A = \frac{2 \times 32 \times 0.2 \times .05}{R} = \frac{0.64}{R}$$

For a three-phase, three-wire feeder the fixed charges would be

$$\frac{0.64 \times 1.5}{R} = \frac{0.96}{R}$$

The total annual cost would be

$$A + B = \frac{0.96}{R} + .03\, C^2 R,$$ which is a minimum when

$$C^2 R^2 = \frac{0.96}{.03} = 32 \text{ and } C R = 5.66$$

With a three-phase, three-wire transmission of bare wire supplied by water power carrying 100 amperes per wire at maximum load, at a line pressure of 20,000 volts, and for a distance of 100,000 feet, the best size of wire should give a drop of 5.66 volts per 1000 feet of wire, under the assumed conditions as to cost of line and power plant. That is, such a line should have an ohmic drop of $C R \times 100 = 566$ volts per wire, and R should be $\frac{5.66}{100} = 0.0566$ ohm. This is between the resistances of 4/0 and 3/0 wire, but nearest 3/0, which would be the most economical size.

The above calculation would probably require some modification in an actual case, as the cost of hydraulic development is apt to be greater than that of steam power. In some cases, also, the selling value of power delivered at the end of the line is such that the value of the kilowatts lost on the line at maximum load must be included as an element of cost. That is, if 100 additional kilowatts of energy could be delivered at the end of the transmission line by using larger wire, and each kilowatt could be sold at $50 per year, the income from the sale of the additional power delivered might more than pay fixed charges on the extra line capacity required.

The application of the foregoing treatment to underground work is not so readily accomplished, since there is no fixed law between weight and resistance for lead-sheathed cables.

For the sake of rough comparison with overhead lines, it is possible, however, to carry through a reasonably accurate calculation for single-conductor, low-tension, paper cable, in sizes between 500,000 and 1,000,000 cir. mils. The average value of such cable is about $1 per 1000 feet per 1000 cir. mils when copper is 20 cents a pound. The resistance of 1000 feet of copper conductor being

$$R = \frac{10.6 \times 1000}{\text{cir mils}},$$ the cir. mils per 1000 feet are $10.6 \div R$.

The value of a two-wire feeder of lead and paper cable at $1 per 1000 cir. mils per 1000 feet is, therefore,

$$\frac{2 \times 1 \times 10.6}{R} = \frac{21.2}{R} \text{ dollars.}$$

With fixed charges at 9 per cent., these will be

$$\frac{0.09 \times 21.2}{R} = \frac{1.908}{R}$$

Assuming station capacity and energy loss as in the case of the overhead two-wire feeder, the total annual cost will be

$$A + B + C = \frac{1.908}{R} + 0.0536\, C^2 R$$

This will be a minimum when

$$C^2 R^2 = \frac{1.908}{.0536} = 35.6$$

and $C R = 5.97$.

With a load of 500 amperes, the resistance per 1000 feet of cable should be $R = \frac{5.97}{500} = 0.0119$ ohm, which is approximately the resistance of a 1,000,000 cir. mil cable.

With a smaller current it would be necessary to use a higher cost per 1000 cir. mils and to use a "cut-and-try" method until the size of cable found to be the best by the use of the formula coincided with that for which the cost was assumed. A little practice will, however, enable one to reach a result by the "cut-and-try" method more quickly than by the plotting of a curve from which the minimum point is taken.

The writer realizes that the results reached from the use of this method of arriving at the best sizes of feeder copper are not applied in practice in many instances, for various reasons. In low-tension networks, for instance, the feeder must be designed to deliver a certain pressure to the mains with a certain set of conditions. Short feeders must, therefore, be loaded heavily and long feeders proportionately less.

In most plants the station capacity required to supply the feeder losses is represented by a range of pressure of about 10 per cent. above that delivered at the feeder end, in the fields of the generators. Any saving made in station capacity by using large feeders is, therefore, not easily realized, since generator capacity in this form is not fully available to carry additional load on the plant.

In the case of alternating-current feeders, however, this saving can be realized, and the principles apply quite strictly where potential regulators are employed on each feeder. In such cases the bus may be run high during the peak of the load, and any feeders which do not require the full bus pressure may be "choked" by the regulator, thus decreasing the ampere load on the armatures of the generators.

The method has been applied on one system where about sixty feeders controlled by potential regulators and supplied through motor-generator sub-stations are operated. In this case it is necessary to add to the generating plant investment the substation investment, which is by no means a negligible item in the fixed charges on generating equipment.

In any alternating system where there is a number of feeders, which is increasing, the application of the general method herein outlined will result beneficially to the dividend account in the long run.

Electrically Operated Refrigerating Plants as Central Station Load

SOME very interesting facts regarding the sale of current for the operation of private refrigerating plants were given at the recent meeting of the Association of Electric Lighting Engineers, of New England, at Springfield, Mass.

The Hartford Electric Light Company, said R. W. Rollins, now has ten motor-driven refrigerating outfits as a part of his load. The motors range from 1 to 15 H. P., and with a rate of about 3 cents a kilowatt-hour, the yearly income up to July 1 has been about $5000. This kind of load is a very attractive one, as it increases in summer when the lighting load is very low, and falls off gradually in the autumn when the lighting load increases. With the rate charged, its economy makes it attractive to the consumer, especially in a season of ice shortage as at present.

W. R. Eaton, of the Cambridge Electric Light Company, described a 7½-ton installation in a large market. A brine circulation system was used to cool a meat room to 35 degrees F., a freezing room to 20 degrees, a butter and cheese room to 37 degrees, a vegetable room to 40 degrees, and a fish room to 45 degrees.

Using natural ice, the cost for cooling these rooms was $11.44 a day, the meat room alone costing $5.72. With the private plant, the cost of cooling all the rooms was $4.02 per 24-hour day at a rate of 2½ cents per kilowatt-hour.

G. R. Stetson, of New Bedford, told of a 15-H. P. installation in a market in that city which was formerly operated by a gas engine. For last year the ice bill was about $685, with ice at $2.25 a ton, and this year the price of ice per ton is about double. With the motor-driven outfit, the cost was reduced to $1.47 a day.

In Boston, said C. H. Herrick, no automatic plants are on the circuit yet, although power is sold at the regular rates to plants running continuously. The largest installation of this kind is a 65-HP. plant in a restaurant. J. W. Cowles said that the situati n was complicated by private organizations selling cold storage on a steam basis.

According to W. R. Eaton, cuts of meat are always dry in an electric refrigerating plant, while using ice in the ordinary way made the meat damp and slimy. With the electric system, also, meat would keep fresh for one or two days longer when placed in a glass case with the coils below. The low rate in the Cambridge market, he said, was the result of the customer's power load, aggregating 42 H. P. in connected motors.

Electric Illumination at the Elks Convention in Denver

THE illumination of Denver during the Elk's convention, held there during the week beginning July 16, was, in the opinion of the visitors to the city, the most artistic and the most richly diversified ever seen at any grand lodge reunion in the history of the order. The large number of visitors were unanimous in their declaration that Denver is justly entitled to its widespread fame as the "City of Lights." It is believed that every person in attendance at the convention will be a strong booster of lights for decorative purposes, so great was the impression made by the elaborate display.

The Denver lodge of Elks spent a considerable sum on its own account to eclipse all other conventions in decorative lighting and their efforts alone resulted in a noteworthy display. The merchants of the city also endeavoured to make the occasion a notable one, and the result was a splendid and most effective illumination of all the large places of business. They vied with each other with considerable spirit to secure the most striking light displays and their attainments are well shown in the illustrations given herewith.

The welcome arch at the Union Depot, illustrated in the August num-

LOOKING UP SEVENTEENTH STREET, IN DENVER, DURING THE ELKS' CONVENTION IN JULY

A STRIKING DISPLAY. AN ELK WITH THE ANTLERS TIPPED BY INCANDESCENT LAMPS

ILLUMINATION OF THE OFFICES OF THE DENVER GAS & ELECTRIC COMPANY

ber of THE ELECTRICAL AGE, was the first piece of lighting to greet the visitors and the comments made upon its beauty evidenced the appreciation which it earned from everyone who stepped within the city's gates. Looking up Seventeenth street, there seemed to be a regular roof of multi-coloured lights with the Elk purple lamps as the dominating colour. This effect was produced from the strings of lights stretched across the intersections of the streets. This same scheme was followed on Sixteenth and Fifteenth streets and the whole made the downtown section as bright as day.

A Steam Turbine Operating on Exhaust Steam

IN a paper read at a recent meeting of the British Institution of Mining Engineers, Wm. Maurice described a generating unit driven by a Rateau steam turbine operating on exhaust steam from a winding engine at a colliery in Hucknall, Nottinghamshire, England.

The steam escaping from the winding engine passes through a large steam reservoir. The latter is designed to accumulate the heat from the steam by the help of water or metal, and to evaporate the water again during the time that fresh exhaust steam cannot be supplied. This freshly raised steam is given to the turbine until fresh exhaust steam can go directly through it.

It is well known that metals have a very low temperature coefficient (that is, they take over heat very quickly and give it back very quickly), and so, if the metals assembled in the reservoir can be supplied during the exhaust steam period of the primary engine with as much heat as will suffice to raise steam from the already boiling water during the time when the primary engine is idle, and the volume of steam so raised suffices to drive the secondary engine, then the purpose of the invention is achieved and the secondary engine can run under a constant speed driven by this artificial supply of steam.

Thus, it will be seen that the secondary engine, that is, the turbine, is supplied during part of its run directly with the exhaust steam from the primary engine, namely, the winding engine. During this period the accumulator or reservoir is nothing more than a common link between the source of the steam and the point of utilization.

During another period, the turbine is fed by fresh steam raised (with the help of the heat stored in the metal contained in the reservoir) from the boiling water, which has been brought to boiling point by the passing and remaining of the exhaust steam during the exhausting period. In the Hucknall installation the accumulator contains 50 tons of scrap-iron pit-rails, assembled horizontally and in parallel layers.

In order to prevent the turbine from slowing down, in the event of the winding engine stopping longer than usual, a direct connection with the main boiler-gallery is made through a reducing valve, which reduces the boiler pressure of 55 pounds per square inch to 16 pounds of absolute pressure. This reducing valve is worked automatically by levers, and is set to admit reduced live steam from the boilers into the turbine, whenever the winding engine remains idle for a longer period than 90 seconds.

It will have, no doubt, been frequently observed that, in order to maintain the required number of draws per hour from a winding engine, the boiler pressure must be kept as near as possible to the blowing-off point. Consequently, when winding is delayed, steam blows off at the safety valves and energy is wasted beyond any possibility of recovery. But by the aid of the automatic reducing valve, an appreciable portion of this otherwise waste steam will go through the turbine, just at the moment when the latter cannot obtain exhaust steam owing to the cessation of winding.

In the case of the Hucknall turbine, it has been noted that there is no appreciable change in its speed when fed with steam from any of the three sources of supply, namely, live steam, exhaust steam, and regenerated steam in the accumulator.

The greater part of the power developed by the alternator is used for haulage in the mine where the plant is installed. Since, under the local conditions, no coal winding can go on without haulage and no haulage can be done without winding, the plant works under circumstances favourable to economy.

Whilst power is wanted for haulage the turbine can be driven by exhaust steam, but if it had to run, say for the purpose of operating electric pumps during the night shift, or to do other work during intervals between coal turning shifts, it would then be necessary to run on reduced live steam. The efficiency of the plant would thus be reduced by nearly 50 per cent., as compared with that of a good type of compound engine.

There is undoubtedly a large margin of surplus exhaust steam escaping into the atmosphere, and it is probable that the full output of the generator could be obtained with little more steam than is supplied by one cylinder of the winding engine.

Glasgow has abandoned municipal telephone operation in competition with the National Telephone Company. The system was sold to the British Post Office, with the understanding that it was to be operated as a branch of that system.

A bill is now before the House of Lords in the British Parliament providing for the supply of electrical fittings by metropolitan borough councils.

The Organization and Conduct of a New Business Department

By S. M. KENNEDY, of the Los Angeles Edison Company

A Paper Awarded Second Prize in the Co-operative Electrical Development Association's Competition

THERE is probably no other kind of business in America to-day which is capable of as much development as is the selling of electric energy. At first glance, this may appear to be a bold assertion, but the more the subject is considered, the more the truth of the statement will become evident. There are countless opportunities for working fields only partially cultivated, for plowing and sowing fields now lying fallow, and for reaching out into the deserts and making them "blossom like the rose."

It matters little what may be the relative size of the city in which a central station is being operated,—whether it contains 5000, 50,000 or 500,000 population,—the opportunities are there in each case and almost begging to be looked after. However, opportunities are not in the habit of rushing at those who sit down and wait for them; they require to be sought. But many a man who is sincerely looking for opportunity will be astonished to find that opportunity has been looking for him and anxious to meet him more than half-way.

Electrical opportunities are everywhere in any city,—on the streets, in the home, in the office, in the factory, in the store, in the work-shop, on the surface, overhead, and underground,—wherever men and women live, labour, eat, and sleep.

NEW BUSINESS

There is no standing still in the electrical business,—a central station is either going ahead or falling back. As a matter of fact, a really healthy electric company should be behind with its new work most of the time, should be rushed with orders and straining to keep up with them. It is not meant by this that there should be inefficient methods, or inefficient help, but that the pressure of constantly increasing demands for electric energy should be impatiently pushing forward the orders awaiting their turn for attention.

But this great pressure of work, these insistent demands for attention, what are they? Just the visible indications of opportunities which have been stirred up, and opportunities which have been met on the way in. The central station will obtain the full advantage of these opportunities by means of its "New Business Department."

OBJECTS

The great problem which central station managers are trying to solve is one of equalization. It is highly desirable to increase the sale of electric energy in every legitimate way, but some ways are more profitable to a company than others. In a growing city it is an easy matter to build up a "peak." But it takes effort and brains to broaden the "peak," to build up a day load and to reduce the difference between the peak load and the minimum demand.

These are prime reasons for the existence of a "New Business Department." It is to this department that the central station manager must look in order that he may obtain a proper load for every hour of each day, and every day of the year.

FOUNDATIONS

In organizing such a department, it is well to consider the requisite foundations upon which to build. In the first place, there should be a corner stone, on which is graven the words:—"Electricity for Everything, and Everything for Electricity." This should be adopted as the motto for all connected with the department.

The remainder of the foundations should consist of:—(1) Energy,—untiring, unswerving energy,—the kind that never stops. (2) Vigilance,—the watch-dog of progress,—the sleepless element that takes advantage of every opportunity. (3) Alertness,—quickness to see an opening for business, and readiness to act upon it. (4) Aggressiveness,—so that old methods and conditions may successfully be combated and changed to conform with modern ideas. (5) Persistence,—in order that prospects may be converted into actualities. (6) Knowledge,—which is the mother of good judgment. (7) Enthusiasm,—the quality which compels by force of belief. This is the combination which oils the mechanism of a business and cements the forces for a common cause. With a proper admixture of each of these elements, the superstructure will grow of its own volition.

STAFF

For cities of 50,000 population and under, the staff of the new business department proper may consist of from one to twelve individuals, depending on the size of the city, the local conditions, and the rate of speed with which certain objects are to be attained.

There has been an inclination in some quarters to look upon this department as an extravagance which tends toward excessive plant investment. But this idea is easily exploded. A properly organized and well operated new business department not only points the way to profitable extension, but increases the value of present investments by developing paying business existing under a company's lines and selling energy during those hours when it would otherwise be wasted, or, at least, not fully utilized.

Let the central station manager select a good man to put in charge of the new business department, and let that man add to his assistants as he feels the necessity, and as circumstances warrant. An energetic man will soon stir up more business and more prospects in a city of 10,000 inhabitants than he can himself handle, and he and those labouring with him will have pleasure in watching the growth of the new business added, as the direct result of their efforts.

THE WORK

It is safe to say that no city on this continent, no street, no block, and no house can claim to be properly illuminated, or to have all the electricity-consuming devices which might be used with advantage. In every city of any size there are hundreds of horse-power in steam and gasoline engines operated at a greater cost than necessary, just because their owners have wrong ideas about electric energy and are not aware of the great advantages to be derived from its use. Many electric appliances could be installed in each household now using electric light.

In every community there are many thousands of dollars in revenue waiting to be picked up from the sale of current, the production of which would not increase the central station plant investment one cent. The people want to know about the possible advantages of electricity, and this curiosity should be stimulated and satisfied by the central station, as it is entirely in line with the growth of its business.

More light and power can be sold to consumers, as well as to non-consumers, but it must be done by hard work. Men with a knowledge of salesmanship and business methods are required to successfully spread the news of electrical possibilities, to swell the number of consumers, and increase the amount of individual consumption.

THE METHOD

There are four ideas the manager must grasp before starting on his campaign, namely, that the public requires education, instruction, persuasion, and demonstration. It is not usual for men or women to want something which they do not know exists. And after they have been taught that something does exist which would better their condition, they require to be instructed as to its advantages.

In a city of 20,000 population, a company may have 3000 consumers, all using light. Perhaps the manager contentedly leans back in his office chair, and, in answer to an inquiry, says, "Yes, business is good, we keep adding to our consumers right along, and must soon increase the capacity of our plant." At the same time, his load curve may resemble the spire of a church. Does he try to broaden his peak? Does he try to equalize, so that there may be a profitable day load? Perhaps he is too busy to do more work himself. If such is the case, then he would better obtain a means of educating his consumers.

His 3000 customers could probably be increased to 4000, but let us stick to the 3000. They are all using light. What do they want first? More light! It is an axiom in this business that the more opportunities there are for using light, the more light will be sold. Some of the residences are without porch lights, hall lights, portable lights, cellar lights, out-house lights, and out-door lights. The stores want more inside lights, more window lights, and more electric signs. The factories and workshops need more arcs and reflector lamps. Good light makes cheerful and efficient workmen, and good workmen deserve good light.

ELECTRIC APPLIANCES

Do those householders know of all the electric appliances that add so much to the comforts of life? Perhaps they do know of some of them, but not from the central station office. And yet those housewives are ready to use electric toasters, chafing dishes, irons, sewing-machine motors, plate warmers, coffee pots, curling tongs, broilers, and dozens of other conveniences, but they must be told about them.

Anything else? Yes, power. Power usually means day load, and that is what the manager is looking for. That city of 20,000 people is using power in intermittent and constant operation. How much of it is electric? Is the manager going to sit down until new factories start and wait for the promoters to come to his office and inquire what can be done? If he does, he will probably have few inquiries. Is he going to wait until those existing power users who have steam and gasoline plants meet with accidents, and then expect to have them ring him up for information? Perhaps he will have a few calls, but he will have fewer orders.

What must be done to obtain these valuable kinds of business? Educate, instruct, demonstrate and persuade. If you want to sell more light, show your customers that they need more. If you want to derive the increased income from the use of electric appliances without increasing your investment, you must create a demand for the appliances. If you want power consumers to hold your plant down during the daylight hours, then show the power users in your city the advantages of electric energy. They must learn of the convenience, cleanliness, and reliability of electric motor driven power. They must be shown the saving in insurance, interest, and depreciation. They must have all these things explained and demonstrated to them. They must become interested, then anxious, and then hungry.

ELECTRIC IRONS

The company with which the writer is connected operates in one city with a population of 225,000, and in seventeen other cities with populations varying from 4000 to 25,000, and has upwards of 30,000 consumers. About eighteen months ago it was decided to stimulate the sale of electric laundry irons for use in private dwellings, hundreds having already been installed in various laundries on the system and found to be giving great satisfaction.

Within twelve months there were installed in residences over 1600 irons, which were all paid for by the consumers using them. Careful data were compiled, and it was conservatively estimated that the average monthly income from each iron was 65 cents, or equivalent to $8 per year. It was also apparent that those who had the irons were highly pleased, and, in numerous instances, were inquiring for other appliances.

Many who would gladly use them, did not have the irons, but they could not, or would not, spend the money to buy them. The company found that electric irons are good things for day load at lighting rates. There is no increased plant line, transformer, or meter investment required. The average income per iron is at least $8 per year; 1600 of them are installed. Why not 10,000? Because the people won't buy them. Well, let us see. Every thousand irons out increases the annual income $8,000; 10,000 irons would mean $80,000! Just like finding it! What was to be done? Invest a little money, take a little risk. Loan the irons to customers who will use them.

That is what our company has done. The first order placed was for 3500 irons. Within twelve months from the time the plan was put into effect the company will have loaned not less than 7500 irons, and there will probably be in use on our system in 1907 10,000 electric irons. That is one way of getting new business and making it easy to obtain more.

BUYING OLD PLANTS

One more reference to the means adopted by the same company to obtain power business. It often happens that a power user may be interested in electricity, but has his money tied up in a steam or gasoline engine and does not wish, or thinks he cannot afford, to invest more. During the past two years our company has purchased such plants, in units averaging 20 H. P. each, to an aggregate of over 1000 H. P. These engines have been re-sold and shipped to territories away from the company's lines, and their former owners are now invariably strong advocates of electric energy.

But engines have been purchased in this manner only where there was no other way of obtaining the electric power business. Owing to the lower cost of motors, most of these exchanges were made without loss to the company, although in some cases it was figured that an initial loss must be met in order to obtain profitable and permanent power business.

WAYS AND MEANS

What must the new business department do to educate, instruct, and persuade the public. The answer is:—Advertise, solicit, exhibit, systematize, and foster existing business.

The success of the central station is first dependent upon good service, but most of the different problems in generation, transmission, and distribution have been satisfactorily solved, and most managers know how to obtain an adequate amount of energy. But the limits to the sale of electricity have not yet been sighted, and the more these limits are sought, the greater distance they seem to be away.

The new business department cannot be divorced from the other departments of the company. It must of necessity keep in touch with the operating and construction ends, must be close to the accounting side, and in constant communication with the customers' department. The manager of this department need not be an engineer, but he must have absorbed a considerable amount of technical knowledge. He need not be an accountant, but he must know how to figure. He need not be a meter reader, a collector, or a trouble-man, but he must know the difficulties of each of these positions. Above all, he must know the public. He must know its failings, its prejudices, its needs, and its opinions.

ADVERTISING

Advertising is one of the mainstays of the new business department, and must receive careful attention. The man who advertises must put himself in the place of those whom he wishes to reach. With this idea before him, he will understand how to attract the attention of the public, where to place his advertisements, and when the psychological moment arrives to produce the best results.

Advertising of any description must attain its object by a well-defined process. It must first attract attention, next promote inquiry, then awaken desire, and finally create a demand.

For the reason that the public cannot all be reached in the same way, it follows that all honest advertising is good. Some people never look at the advertisements in the daily papers, but will eagerly scan each advertising page in a magazine. Others never see an advertisement in a periodical, but yet their eyes catch the notice on a bill-board, or the card in a street car. Again, there are others too absent-minded to note anything on a bill-board or in a car, but put a circular or letter in their hands and it will be read from beginning to end. Consequently, to reach every class, use every medium of attracting their attention. You need not go after all at once, but go after them somehow.

NEWSPAPERS

Newspaper advertising pays in many ways. Its returns are both visible and invisible. Considerable advertising space is often taken to influence the press. The friendship of local papers is important. Foster that friendship, but do not neglect the space you take just because you think it is there always. That space is valuable to you in proportion to the circulation of the paper, and the editor may be valuable to you for the same reason. If your advertisements are built right, if they attract attention and say something, they will help your business and increase your income.

It is a good plan to tell one thing at a time, to change the copy frequently so that it will not become stale, and to use a snappy, concise style that will gradually draw a regular following of readers who will look for your advertisement in the paper just to see what you have to say. What you print will be read by consumers and non-consumers. Say something to each. The former should be using more current. Point out to them where they need more. The latter need to begin. Show them where they will be better off. Create the desire.

It is not necessary for you to be an advertising expert. Know your own business. Be thoroughly acquainted with the public needs. Talk in the advertisement as you would to a prospective customer sitting in your office. Attract attention; then be short, direct, and crisp, and let your words show that you believe in what you say, and they will carry conviction with them.

Regarding the many valuable media of advertising other than newspapers, the business manager must of necessity be governed by local conditions and by his own experience as to the advantages of each class. It is desirable to vary the manner of publicity, but to keep at it all the time, remembering that constant drops of water will wear away the stone, and that indifference may gradually be changed to interest, and antagonism to friendship.

CIRCULARS, ETC.

The mailing of circulars separately or along with bills is a successful way of arousing interest, but the circulars must be carefully prepared, printed on good paper, and always artistic. Neat booklets or folders should be interchanged with the circulars, and each should draw attention to one subject only. Bill-boards are splendid for special announcements, and catch the eyes of many who will not read the papers. He who runs may read a poster, and many read and remember.

Street car advertising is also valuable to impress an idea on the public. If a man is sitting in a car for ten or fifteen minutes with one of your advertisements opposite him, he will read it, and if what you say is catchy or important, he will not forget it.

"FOLLOW-UP" LETTERS

"Follow-up" letters are a dignified and desirable means of drawing the attention of selected people to a subject which should be of special interest. They are always productive of good results. These letters should have a personal touch to them, and should be neat and attractive in style and diction, avoiding altogether the appearance of a general circular. By this means the individuals you wish to reach are talked to without chance or haphazard.

ADVERTISING ON BILLS

One of the best ways of drawing the attention of existing consumers to a subject is to use the backs of their monthly bills. If you wish to advertise electric appliances useful in a home, put a "snappy" notice on the backs of the bills. If you wish to have merchants consider window lighting, electric signs, or fans, talk to them briefly on the backs of their bills. Say something different each month. Every man and woman will look at the bill to see the amount. Let them also notice a bold line reading, "See Other Side." They will then turn the bill over and read your advertisement. That is what you want them to do.

The business manager should do

his advertising thoroughly, intelligently, and systematically. If he cannot do it himself, or have some one on his staff do it, he would better pay an "ad-smith" to take the details of the whole matter off his shoulders.

SOLICITING

Advertising in the electrical business is to arouse curiosity, invite investigation, induce the reader to ask questions, and thus prepare the way for getting business. But it requires a personal interview to close a contract. The prospective consumer must either hunt someone up, or someone must hunt him up, in order to bring matters to a desirable climax. It is a good plan for a representative of the company to do the hunting. The man who reads the advertisement might have good intentions, but a poor memory.

The new business department requires good solicitors. There are some lines in which a solicitor requires only to be a good talker, but it is not so in selling light and power. A good talker is all right, but he must be honest, earnest, and straightforward, and what he says must carry with it the ring of truth. The solicitor meets the people in their homes, offices, and places of business. He represents the company, and the public is going to judge the company by the actions and words of the solicitor. Often he is the only one about the company whom the customer knows.

The president, directors, and officers may be men of standing, but the average customer does not know anything about them. He judges the officers by the kind of men they send out to talk to him. Do not think that any kind of a man can solicit. Have men who know, men who can make friends, men who can mix well, and men who wear well.

There is a big difference between a man coming to you to do business and you going to him. The first presupposes a desire in him to act, the second a desire in you to induce him to act. Consequently, solicitors should be trained and instructed.

REGULAR SOLICITORS' MEETING

It is well for the business manager to gather his staff around him at least three times each week to discuss matters in hand, and to answer questions and smooth out difficulties. New conditions to be met are constantly arising. Information is constantly coming in which must be distributed. Reports about new buildings, new building permits, and new tenants must be dealt with, and often a daily meeting is necessary, and advantageous.

Direct solicitation is the safest and surest way to obtain business, and the solicitor must be equipped for his work. The electric company has much to do to overcome competition, indifference and inertia, and it is through the solicitor that a large amount of this active and passive opposition may be removed. He must educate and demonstrate. He must make the public realize that what his company is selling is something in which everyone should be interested, something that lessens the cares and responsibilities of life, something that is superior to everything else for doing similar things, something that reduces work, lightens labour, and saves the public's pocketbooks from certain ravages.

SOLICITOR'S TACTFUL WORK

It is essential that solicitors should not be too technical in their talks with prospective consumers. There is nothing to be gained in befogging a man by injecting into a conversation a mixture of amperes, ohms, and volts. The solicitor is not selling kilowatts; he is selling light. He is not selling amperes; he is selling heat and power. If he has acquired technical knowledge, let him forget it when talking to an ordinary man or woman, and he will sell electric current with less trouble.

Those engaged in the electric business are apt to forget that the public does not know as much about it as they do. A very large percentage of the community does not know of the conveniences and simplicity of handling the current, even when they have it for lighting their homes. Many people have a fear of electricity on account of its mysterious nature, some thinking it as dangerous as lightning. Here is where the careful work of the solicitor may do good every day. He can point out the safety of electricity in the home, the impossibility of upsetting electric lights, with the reduction of fire risk, the dispensing with matches where there are children and careless people, the abundance of pure air, the saving of doctors' bills, and the convenience of the many wonderful electrical appliances which are adapted for house use.

To the merchant, the solicitor points out the advantages of electric light for showing his goods, for keeping his ceilings and store clean by an absence of smoke and smut, for reducing the heat in summer, and permitting good air at all times, for improving the decoration of his windows and keeping them clean winter and summer, so that the public may see what he wishes to display. Then the solicitor shows him the score of electrical devices which may be operated to advantage inside his store, and help him make money. And, lastly, the solicitor takes the merchant to the door and points out how and where an electric sign will work for him while he sleeps, how he can burn his name and business into the public mind, and how the company will take care of the sign, turn the current on and off at the proper times, and relieve him of all responsibility in the matter.

The power user has much to learn, and, to a great extent, the solicitor must be his instructor. In a factory in the crowded part of the city, the solicitor sees probably 50 per cent. of the power generated being wasted and dissipated in shafting and belting, ten times as much space as is necessary given up to engines and boilers, twice as much money invested in the power end as there should be, and, consequently, twice as much interest and insurance, and four times as much depreciation continually piling up. He probably finds plenty of noise, odour, dirt, and inconvenience, and high-priced skilled labour to keep his wheels moving.

The solicitor can show that electrically-driven machinery represents economy of power by means of direct-connected units; that motors occupy little space, and may be taken off the floors and stuck on the walls and ceilings; that they cost less than half the price of any other kind of power machinery; that they are clean, noiseless, convenient, and reliable, and do not require skilled labour to operate them.

APPLIANCE SHOW-ROOM

The work of the solicitor may be greatly aided by the company having a show-room in which all kinds of electrical appliances may be seen, and their usefulness and convenience demonstrated. The public may thus become familiar with the workings of the different apparatus, and the solicitor will have an advantageous place to which he may invite prospective consumers, and there explain the actual operation of what he wishes to sell.

Too much care and attention cannot be given to the arrangement and fitting-up of this room. Lamps of every size and design should be tastefully displayed, so as to obtain the best effect with each. With them should be shown the current-saving devices, and also electric meters in operation. The latter will help to make the people familiar with the meter's mechanism, and tend to inspire confidence.

There should also be specimens of all kinds of practical appliances which may be used in the house, office, store, and workshop. In short, a continuous exhibition of electric apparatus and what may be done with them. In this show-room plenty of small booklets should be always at hand, giving illustrations and concise information regarding the different kinds of appliances, so that those inspecting them may have something to carry away to refresh their memories and arouse the interest of others.

ELECTRIC OFFICE DISPLAY

The central station manager must show his belief in what he produces and sells, by using freely what he wants others to buy. He preaches that an electric sign is the best kind of an advertisement. Does his company use one? He advocates a well-lighted store and a brilliant window, but how about the company's office? Is there plenty of light, and is it burned far into the night? Has he electric fans, foot-warmers, and radiators installed for the benefit of employees and customers? Let deeds, as well as words, show he has plenty of confidence in his own product.

There must be system in advertising, system in laying out the work for solicitors, system in noting the results of advertising, and the returns which solicitors bring in, system in handling what has to be done and what has already been accomplished, system in noting sales, terms, proposals and contracts, records of buildings to be constructed, names of owners, contractors and tenants, and the particulars regarding the probable requirements of each. In records of prospective power consumers, complete information is necessary about present installations, kind of machinery, maker's name, horse-power, use and hours of operation.

CARE OF CUSTOMERS

In all branches of the work, system is needed, but not the kind of system which becomes a tax and a burden. The longer the manager is at his work, the longer he is dealing with the people, and the longer he is trying to sell electricity, the more will he be impressed with the fact that the best advertisement is a pleased customer, and the best possible solicitor is a consumer who is satisfied. All the work of his department is practically wasted if the new business taken on is not properly cared for.

It is a regrettable fact that, as a rule, there does not seem to be a proper sympathy between the public and the electric company. They do not seem to understand each other. The public is too liable to think it is being overcharged or imposed upon, and the employees of the company to think the public "kicks" too much.

The company is largely responsible for this condition. Employees are not trained to be courteous and polite, to put themselves in the customer's place, to understand why they ask questions about what they do not know, and why they "kick" when those who are taking their money do not give them proper attention and civil answers. The importance of this subject cannot be over-estimated, because it is "up to" the company to do everything possible to establish and maintain friendly relations with its customers.

GOOD SERVICE

Good service requires that there should be polite and attentive clerks, collectors, meter readers, and trouble-men; that complaints shall be listened to and promptly investigated, and that the settlement of disputes and adjustment of claims shall not be side-tracked and postponed beyond reason. The very existence of a company depends upon the good-will of its customers, and for this reason inattention and discourtesy on the part of any of its employees should be considered unpardonable.

The agents of the new business department go out after business. They approach a man in his own house or office, and then it is that a man is liable to talk freely of how the company has treated him. If the treatment has been bad, the agents' chances of doing more business are very slim. If the treatment has been good, the chances for more business are excellent. The best means of advertising a business is for it to be advertised by its friends. If a man is a consumer, look after him. If he has a complaint, or is in trouble, give his case immediate attention. His general opinion may be that corporations have no souls, but he will find that individuals in the corporation have, and it is by the work of the individuals that he is going to judge your particular corporation.

If a man is a power user, he is depending on that power to help him earn his daily bread. He may have a large number of employees, or he may be operating a motor alone himself. In either case, if the power goes off, or some trouble occurs with his service, he is put to inconvenience and expense until the trouble is rectified. As a rule, when he has trouble with his motor or service, the first thing he does is to call up the electric company. The first thing the electric company should do in such a case is to give this man's trouble the right of way. Whether the cause of the trouble is the fault of the company or of the consumer, does not much matter; the fact that the consumer is shut down is sufficient reason to see that he is put in running order again as quickly as possible.

One of the most successful ways of convincing prospective power users that the energy you have to sell is the energy they need, is to take them to plants that are being operated by electric power for similar purposes to that for which they would use it. Then have these consumers who have been using power for some time tell the prospective customer how electricity works, its advantages, its troubles, if any, and the cost of operation.

The prospective customer may think that the agent of the company is prejudiced. Besides, the man who is trying to sell him a steam or gasoline plant has probably told him something just the opposite to what your agent has said. But if he is going to run a machine shop, or a planing mill, or a foundry, or a peanut stand, take him or send him to some of your customers who have been running similar plants with your electric power. If you have treated your customers right, they will honestly help you to win others.

RESULTS

However, results are the best test of all work, and there is nothing problematical about the results to be obtained if the new business department is operated with diligence, intelligence, and perseverance. Let the department manager cultivate among his assistants a spirit of pride in the work. Let him encourage and enthuse them, so that a healthy emulation may exist, an emulation to excel each other for the benefit of the company's business, and to pull together so that the successes of to-day may be but the stepping stones for the achievement of to-morrow. Let there be politeness, attention, and courtesy in all ranks and at all times. Under such conditions the central stations will surely prosper and the tiny stream of new business which once had to be coaxed and persuaded will eventually begin to flow as a river, and continue to grow in force and volume day by day.

The Direct Production of Copper from Electrolytic Solution

It has been the aim of electro-metallurgists, ever since copper refining was introduced by Messrs. Elkington, in the year 1869, to increase the rate at which copper can be deposited in a smooth form, without any considerable increase in voltage, which means increased power and corresponding cost. The object of increasing the rate at which copper can be deposited is to reduce the capital outlay, and the amount of copper under treatment, which is an item of great importance in works of any size.

The current density employed in electrolytic refineries has been in-

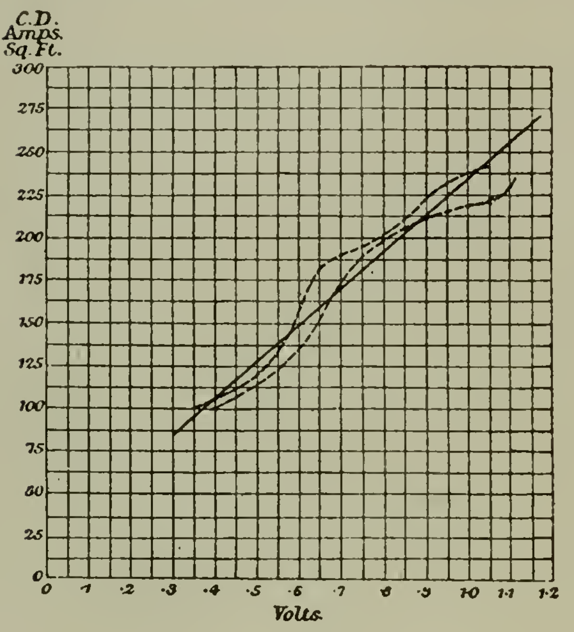


FIG. 1.—DIAGRAM SHOWING THE CURRENT DENSITY IN THE COWPER-COLES CENTRIFUGAL PROCESS

creased from about 8 or 10 amperes, as originally employed by Messrs. Elkington and Messrs. Elliots, of Birmingham, England, to 20 amperes per square foot, as at present employed by the Anaconda works, in the United States.

The usual current density employed in the centrifugal process described here is 200 amperes per square foot of cathode surface, the voltage at the terminals of the depositing cell being 0.75, as shown on the diagram, Fig 1, the figures for which were obtained in actual practice.

To enable finished products, such as copper tubes, sheets, and wire, to be made direct in one operation from crude copper by electro-deposition, it is necessary to greatly increase the rate at which the copper is deposited, as compared to the rate at which copper can be electrically refined, otherwise the capital outlay on the plant is so heavy as to render the process too costly for practical purposes.

The conditions that are necessary to enable copper to be quickly electro-deposited can be summarized as follows:—

The electrolyte must be rapidly circulated so as to prevent the electrolyte being deprived of its copper ions in proximity to the cathode.

The conditions must be such that no metal other than copper is deposited.

The electric resistance must be kept low.

The ideal electrolyte would be one that is chemically inert as a solvent, but capable of dissolving copper electro-chemically, and having a low specific electrical resistance. These conditions have, so far, been met by the use of an acidulated copper-sulphate solution, although this is far from ideal; but it is cheap, and is capable of producing exceedingly pure copper from comparitively impure copper. It has been estimated that the resistance of the circuit is approximately as follows:—15 per cent. metallic resistance, 60 per cent. electrolyte, including the transfer resistance, 20 per cent. due to poor contacts, and 5 per cent. due to counter electromotive force.

Various attempts have been made from time to time to further increase the current density by using mechanical means for keeping the copper smooth during the process of deposition. The best known of these is the Elmore process, which employs an agate burnisher, which continually traverses the surface of the copper being deposited; and the Dumoulin process, which employs a sheepskin rubber, the object being to insulate, by coating with grease, the raised portions of the copper as soon as it becomes rough, so as to cause the lower portions of the copper to build up to the same level: the impingement of the electrolyte against the surface being deposited on has also been tried.

The Cowper-Coles centrifugal process is distinct from any of these, in, that it consists of revolving the man-

FIG. 3.—A CONE ON WHICH COPPER HAS BEEN DEPOSITED WHILE THE CONE IS ROTATING. THE EFFECT OF THE DIFFERENT PERIPHERAL SPEEDS IS CLEARLY SHOWN

drel on which the copper is deposited at a critical speed. It is found that for a given current density the mandrel must have a certain peripheral speed, the greater the speed the greater the tensile strength of the copper. The result of revolving the mandrel at this comparatively high-speed is that every molecule, as it

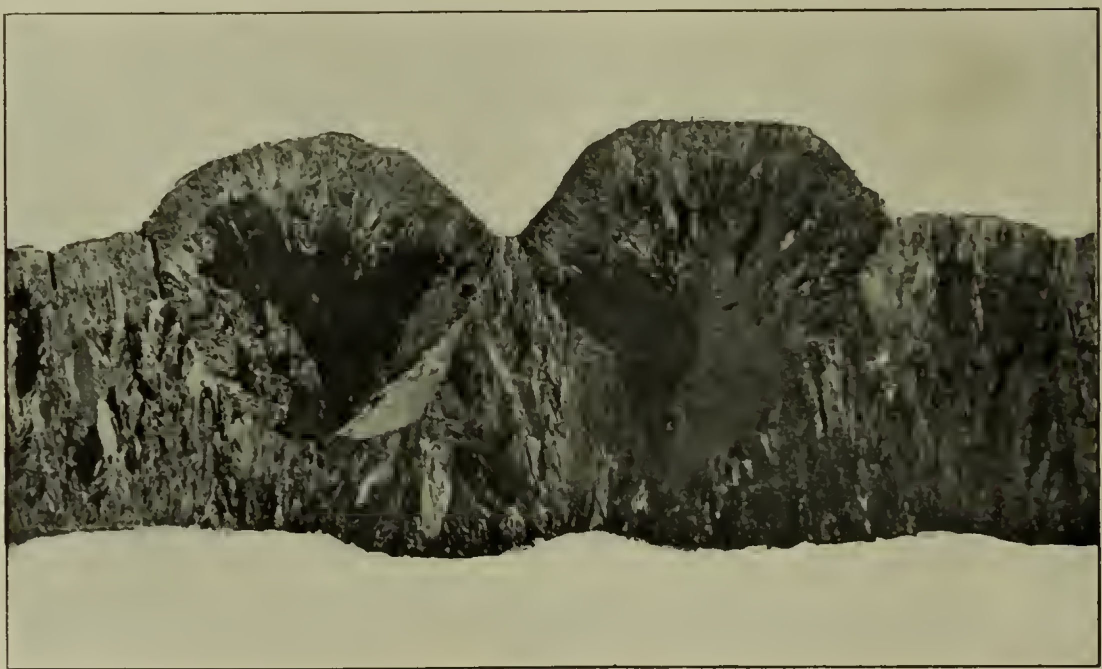
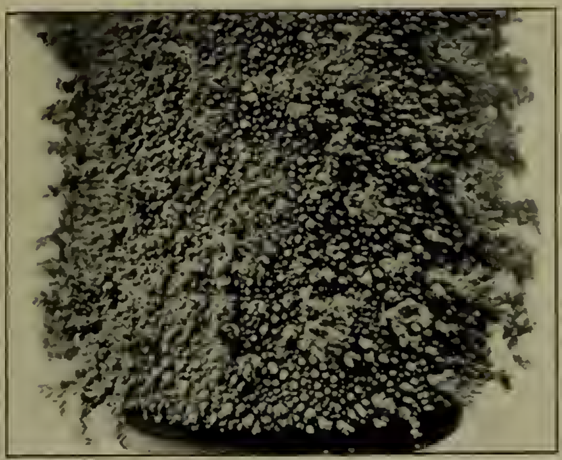
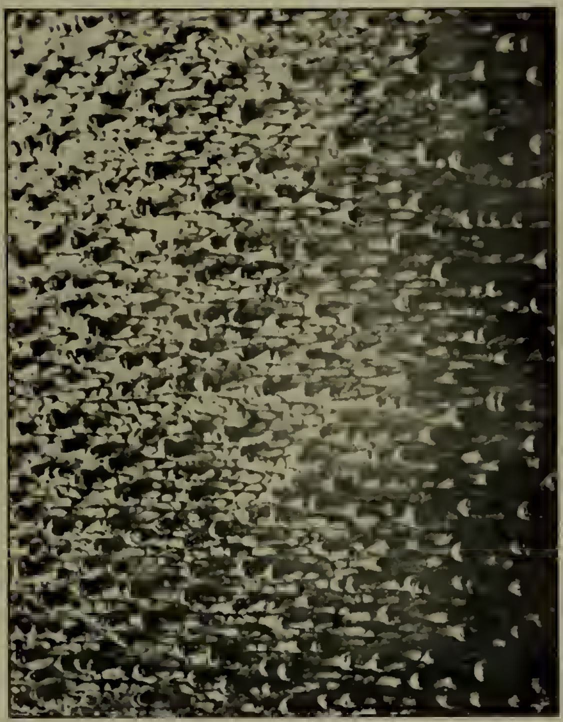
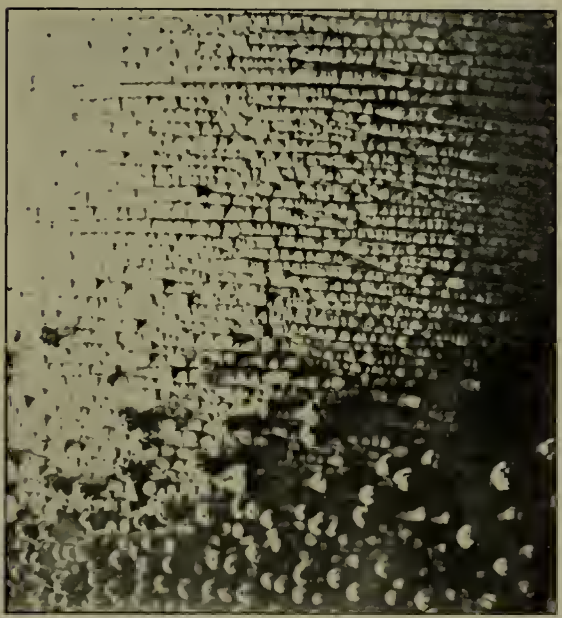


FIG. 2.—A MICROGRAPH, SHOWING THE CRYSTALLINE STRUCTURE OF ELECTRICALLY DEPOSITED COPPER AND THE FORMATION OF NODULES







FIGS. 4, 5 AND 6.—SHOWING COPPER DEPOSITED BELOW THE CRITICAL SPEED

is deposited, is burnished or rubbed down so as to produce a tough fibrous copper, the usual order of things being reversed, the present practice being to put the mechanical work into a mass of copper instead of treating each molecule as it is deposited.

The centrifugal action plays an important part in this process, as it enables very impure solutions to be used, that is, solutions containing a considerable amount of foreign matter in suspension, as the impurities are thrown off by centrifugal force and the rubbing action of the electrolyte, thus preventing the formation of any nodules.

Fig. 2 shows, under a moderate magnification, the way these nodules are built up, and the crystalline structure of the copper, crystals being formed at right angles to the surface on which the copper is deposited. When these nodules are removed by force, and examined under the microscope, it will be found that at the root of each there is a small speck of foreign matter. These specks of impurities are also found to cause corrosion of the finished copper tube or sheet, when subjected to salt water or other corroding agencies, as they are usually electronegative to the copper.

The method employed for determining the critical speed for varying conditions was a revolving cone, as shown in Fig. 3, from which it will

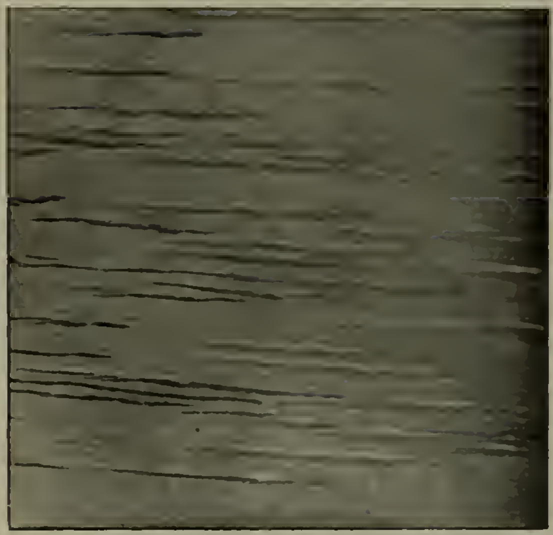


FIG. 7.—COPPER DEPOSITED BELOW THE CRITICAL SPEED

clearly be seen how the nature of the copper varies, according to the peripheral speed; at the smallest diameter the copper is rough and brittle, at the larger diameter it is smooth and tough. Figs. 4, 5, 6 and 7 show deposits of copper ob-

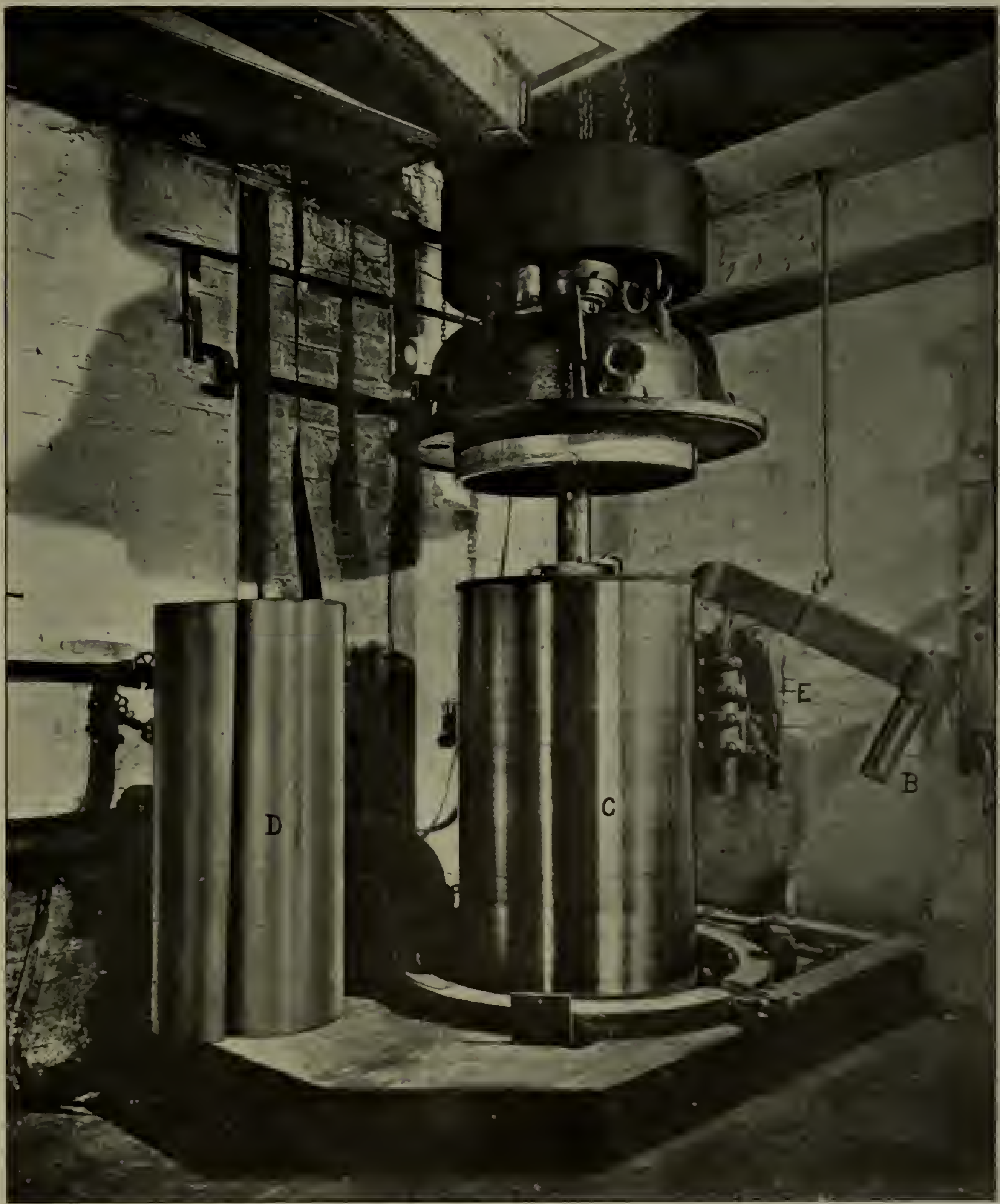


FIG. 8.—PLANT FOR DEPOSITING LARGE COPPER CYLINDERS

tained before the critical speed is arrived at.

A recent application of the process is the production of large copper cylinders for printing purposes, in connection with the textile industry. A plant for such a purpose is shown in Fig. 8, and consists of a highly polished mandrel C, corresponding to the internal dimensions of the finished cylinder, or continuous band that is to be produced.

When it is desired to produce a sheet instead of a cylinder, an insulating strip is put down the side of the mandrel. A copper sheet D thus produced is shown standing on the left-hand side of the vat. The mandrel, or cathode, is driven at the desired speed by means of a belt and pulley; the anodes are cast copper, suspended on a copper ring, the current being led to them by means of the conductors A. The cathode connection is made by means of a mercury cup placed on the top of the driving spindle, and the arm B, which fits on the top bracket.

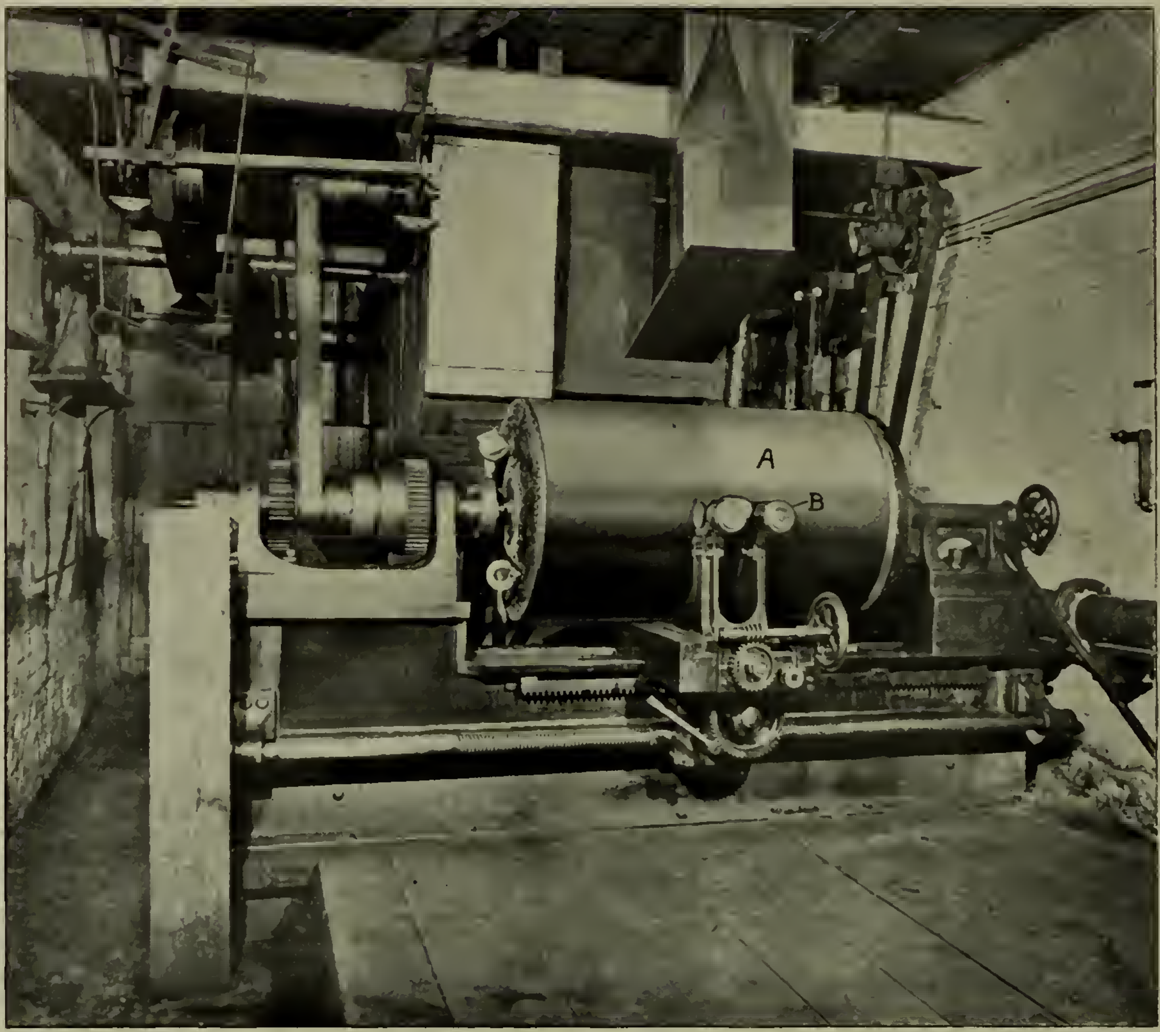


FIG. 11.—MACHINE FOR EXPANDING OFF LARGE COPPER CYLINDERS

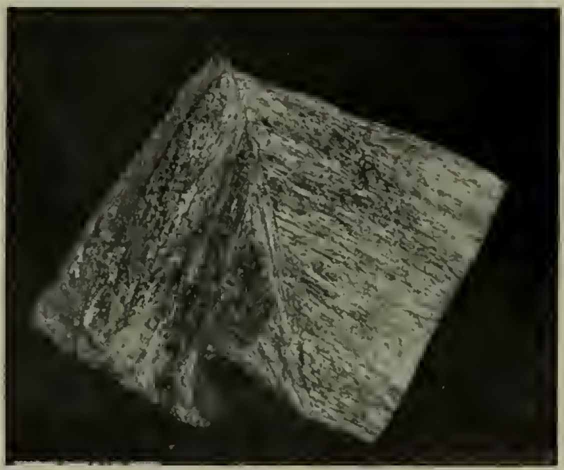


FIG. 9.—CAST ANTIMONY, SHOWING LINES OF CLEAVAGE

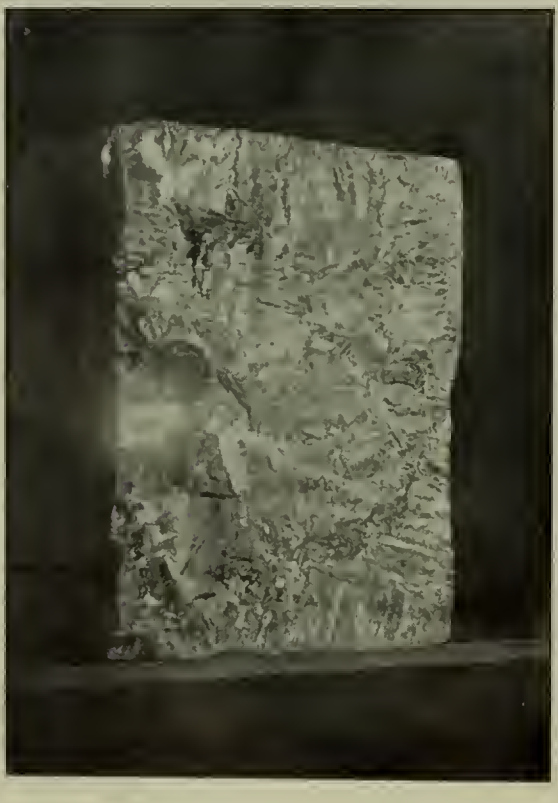


FIG. 10.—CAST ZINC, SHOWING LINES OF CLEAVAGE

The cylinders are made quite thin—about 1-32 inch in thickness—and are expanded off on especially-constructed lathes. As shown in Fig. 11, a roller B is caused to traverse the service of the deposited copper A, so as to slightly stretch or expand it. After the roller has passed over the copper once or twice, it is found that the cylinder can be easily drawn off.

Another point of particular interest about the Cowper-Coles process is the method of making wire or strip. The apparatus employed is shown in Fig. 12, from which it will be seen that the vat is annular in construction. Such an arrangement has the great advantage that there are no working parts in the acid electrolyte, and that the mandrel can readily be withdrawn, and the amount of electrolyte required is greatly reduced. Such a vat is capable of making wire three or four miles in length.

The mandrel for the production of wire has a fine spiral scratch made on the surface, as shown in Fig. 13. This scratch is angular, not of a rounded section, otherwise the copper will not divide. The effect of this scratch is to alter the crystalline structure of the deposited copper, and form a line of cleavage similar to those formed in cast metals, with sharp angles, as in Figs 9 and 10. A microphotograph of a section of copper strip thus produced is shown in Fig. 14. The copper is deposited in the usual way, but when the end has once been started, it can be unwound in a continuous strip, as shown in Fig. 13.

Copper obtained by this process gives a remarkably high tensile strength. Copper tubes without any drawing have been given a maximum stress of 17 tons, and a tube after drawing has stood a pressure of 3000 lb. per square inch—thickness of metal, 0.063 inch—without showing any signs of distress; and sheets,

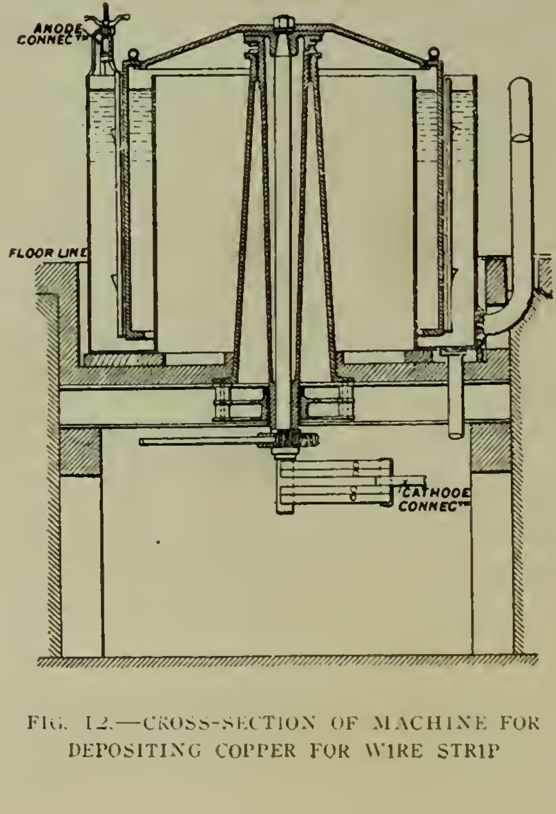


FIG. 12.—CROSS-SECTION OF MACHINE FOR DEPOSITING COPPER FOR WIRE STRIP

FIG. 13.—UNWINDING COPPER STRIP FOR WIRE

without rolling, have given a maximum stress of from 28 to 34 tons per square inch.

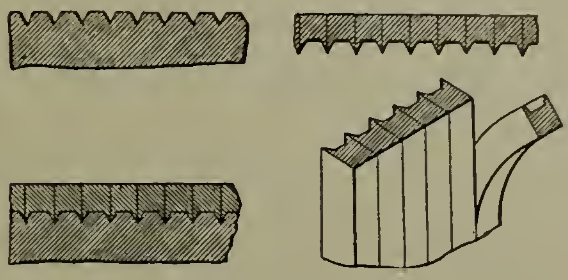
It is found that very pure copper is obtained by the centrifugal pro-

FIG. 14.—A MICROGRAPH OF A SECTION OF WIRE STRIP

cess, even when very high current densities are employed and with a solution containing much foreign matter in suspension, as shown by the following analysis:—

	Per Cent.
Iron	0.0189
Arsenic	0.0015
Lead	0.0013
Antimony	0.0010
Bismuth	0.0018
Silver	Absent
Nickel	"
Sulphur	"
Copper (by difference)	99.9765

The following are some of the chief advantages claimed for the process:—The copper is refined and manufactured into sheets or tubes in one operation, the copper being of a hard nature, similar to that which is cold rolled; the process is at least ten times faster than any existing electrolytic process; a high current can be employed without deteriorating the quality of the copper; there is no risk of lamination, as no burnisher is employed; the plant is



FIGS. 15 AND 16.—SHOWING SECTION OF CYLINDER ON WHICH WIRE STRIP IS DEPOSITED AND SECTION OF WIRE STRIP BEING TORN OFF

simple, and free from mechanical complications; the amount of copper locked up for a given output is small compared to other processes; anodes of very impure copper can be used as compared to the anode copper used in other systems. The process is being introduced by Messrs. Sherard Cowper-Coles and Company, Limited, 82, Victoria street, Westminister, London. The King's Norton Metal Company, of King's Nor-

FIG. 17.—A MICROGRAPH OF DEPOSITED COPPER

ton, near Birmingham, have acquired an interest in the process and are now erecting a plant.

A portable telephone system is being installed in Detroit by the Michigan State Telephone Company. Portable telephones carried in automobiles, carriages or wagons may be temporarily connected at different points in the city.

Economy of Electric Power in Collieries

ACCORDING to S. T. Boam, in a paper read before the British Colliery Managers' Association, recent tests at a colliery electric plant having horizontal engines showed a total steam consumption of 76,590 pounds per twenty-four hours.

If all the various steam engines were replaced by motors with an efficiency of 90 per cent., then the brake horse-power or electrical horse-power required to take their place would be 123.3 H. P. per hour, or for nine hours per day, 1100 electric horse-power hours, which gives an efficiency of 87 per cent. and requires the dynamo engines to give 1276 I. H. P.-hours, which involves an actual steam consumption of 32.7 pounds per I. H. P. per hour. Therefore, the total steam used in working by electric motors would be 41,725 pounds per day, against 76,590 pounds used by the engines as at present, or a saving of 34,865 pounds per day.

Now with the assumption that one pound of coal will evaporate 7 pounds of water at 100 pounds pressure, the saving would be 2 tons 4 cwt. of coal per day, which, in 260 days to the year (five days per week), would be a saving of 572 tons of coal per year. There would also be a saving in oil, stores, wages; thus we see there is a considerable saving in favour of electric motor over auxiliary steam engines on the surface.

Owing to its greater conductivity copper wire was long ago substituted for iron in the more important telegraph circuits. Recently, however, there is a tendency to revert again to the iron wire in certain districts, particularly those in which sleet storms are prevalent and also where the lines pass through wooded districts. The Postal Telegraph Cable Company, as pointed out in the "Telegraph Age," is now improving its wiring through such districts. At exposed places in the Alleghany Mountains iron wire has been substituted for copper, and its great tensile strength has made it much more serviceable. To get the desired conductivity nothing smaller than a No. 6 wire is used. In the West, out through the mountainous districts, the copper wire is still retained, as sleet storms are not so prevalent at the higher altitudes, and because the character of the timber is such that little difficulty is experienced from blown-down limbs of trees breaking the wires.

The Testing of Alternators in Central Stations

By SEBASTIAN SENSTIUS, of the Triumph Electric Company

IN central stations, the testing of alternators along the lines generally in use in the shops of the manufacturer is seldom feasible. Among the tests which can readily be carried out, may be mentioned those for determining the saturation curve, the short-circuit curve, and the temperature rise of the alternator.

For the purpose of obtaining the two curves, the alternator is driven by its prime mover. Exciting the fields, with open-circuited stator winding, and plotting the generator voltages as ordinates and the exciting field currents as abscissæ, gives the saturation curve. Exciting the fields, with short-circuited stator winding, and plotting the short-circuited currents as ordinates and the exciting field currents as abscissæ, gives the short-circuit curve. Both curves give the data to predetermine the regulation with any load and any power factor.

The heating of an alternator can best be obtained by throwing it in parallel on the line. Should this not be feasible, one of the methods suggested in the author's paper on the subject ("Heat Tests on Alternators," Proceedings American Institute of Electrical Engineers, June, 1906) can be resorted to.

It is evident that the tests mentioned are easily made. With the efficiency test, one considered very important by central station managers, it is a difficult matter. In this case, the data furnished by the manufacturer are wholly relied upon. The factors which enter into the calculation of the efficiency are the output, the copper losses in armature and field windings, the losses in friction and windage, and the core losses. Whereas the determination of the copper losses offers no difficulties, the measurement of the core losses, and of the friction and windage, is considered next to impossible in a central station.

In explanation of this fact, we have only to consider by what method these losses are usually measured. The alternator must be driven by a motor, the efficiency of which must be known for different loads. The sum of the friction, windage, and core losses of the alternator equals the input of the motor times the motor efficiency. Now, this method can be applied only on belted alternators, provided a motor of suitable capacity is at hand, which usually is not the case.

For alternators connected to reciprocating engines or to turbines, no method of testing the core losses has thus far been proposed. A certain indirect core loss test is employed. It consists in making a small transformer, built up of laminated steel of the kind employed for the stator. The core loss per pound of transformer steel at various magnetic densities is measured by means of a wattmeter, and the core loss of the alternator is calculated on the basis of the core-loss curve obtained from the transformer test. This method, at best, is a very crude one, and yields results varying from six-tenths to four-tenths of the actual losses.

The writer prefers the following arrangement, which is more accurate than the other method. The alternator is run as a synchronous motor, the impressed voltage is varied, and the excitation current adjusted to eclipse all lagging currents. Under these conditions, the input of the synchronous motor equals the terminal voltage times the stator current, and this energy is used up in stator copper losses, core losses, friction, and windage.

Since the resistance of the stator winding can be measured, the copper losses can be separated from the other losses. The separation of the core losses from the losses in friction and windage is necessary only in the case of direct connection to reciprocating engines, because in computing the efficiency, the latter losses are charged to the engine. This will be explained later.

Given a 60-cycle 3-phase alternator of 115-KW. capacity and 2200 volts pressure, we will proceed to compute its regulation and efficiency.

PREDETERMINATION OF THE REGULATION

The predetermination of the regulation of any power-factor load is usually preceded by a predetermination of the regulation on zero power-factor load. Electrical literature contains many valuable contributions to the latter subject. Among the many methods advanced, the one which the author considers to be best adapted to the needs of the central station engineer, and which is accurate enough for all practical purposes, is that of Torda Heyman.

In Fig. 1, curve $O\ U\ B$ represents the saturation curve of the alternator obtained by driving the latter by its prime mover and by taking readings of the generated voltage as a function of the exciting current. Curve $O\ G\ C$ represents the short-circuit curve obtained by short-circuiting the stator winding and taking readings of the short-circuit current as a function of the exciting current.

To deduce from curves $O\ U\ B$ and $O\ G\ C$ the regulation curve on zero power-factor load, Mr. Heyman first plots curve $D\ T\ M\ E$, which is obtained by plotting to any convenient scale the ratio

$$\left(\frac{\text{amperes exciting current}}{\text{generated voltage}}\right)^2$$

as a function of the exciting current. Since the ordinate is divided to suit a division of voltages between 0 and 2800 volts, we should try to obtain for curve $DTME$ the same scale.

Taking, for instance, an exciting current of $32\frac{1}{2}$ amperes, its corresponding voltage on the curve OUB is 2765, and the ordinate of curve $DTME$ would be

$$\left(\frac{32\frac{1}{2}}{2765}\right)^2 = 0.000139.$$

But this is too small on the voltage scale. We, therefore, multiply it by any large number to make it come in the neighbourhood of 2200 volts. Such a number, for instance, is 1.3×10^7. The ordinate of curve $DTME$ for an excitation of $32\frac{1}{2}$ amperes is, therefore,

$$\left(\frac{32\frac{1}{2}}{2765}\right)^2 \times 1.3 \times 10^7 = 1800$$

(point E). For an excitation of 17.75 amperes, which corresponds to 2200 volts on the saturation curve, we would get an ordinate of

$$\left(\frac{17.75}{2200}\right)^2 \times 1.3 \times 10^7 = 850$$

the ordinate of point M.

A little consideration will show

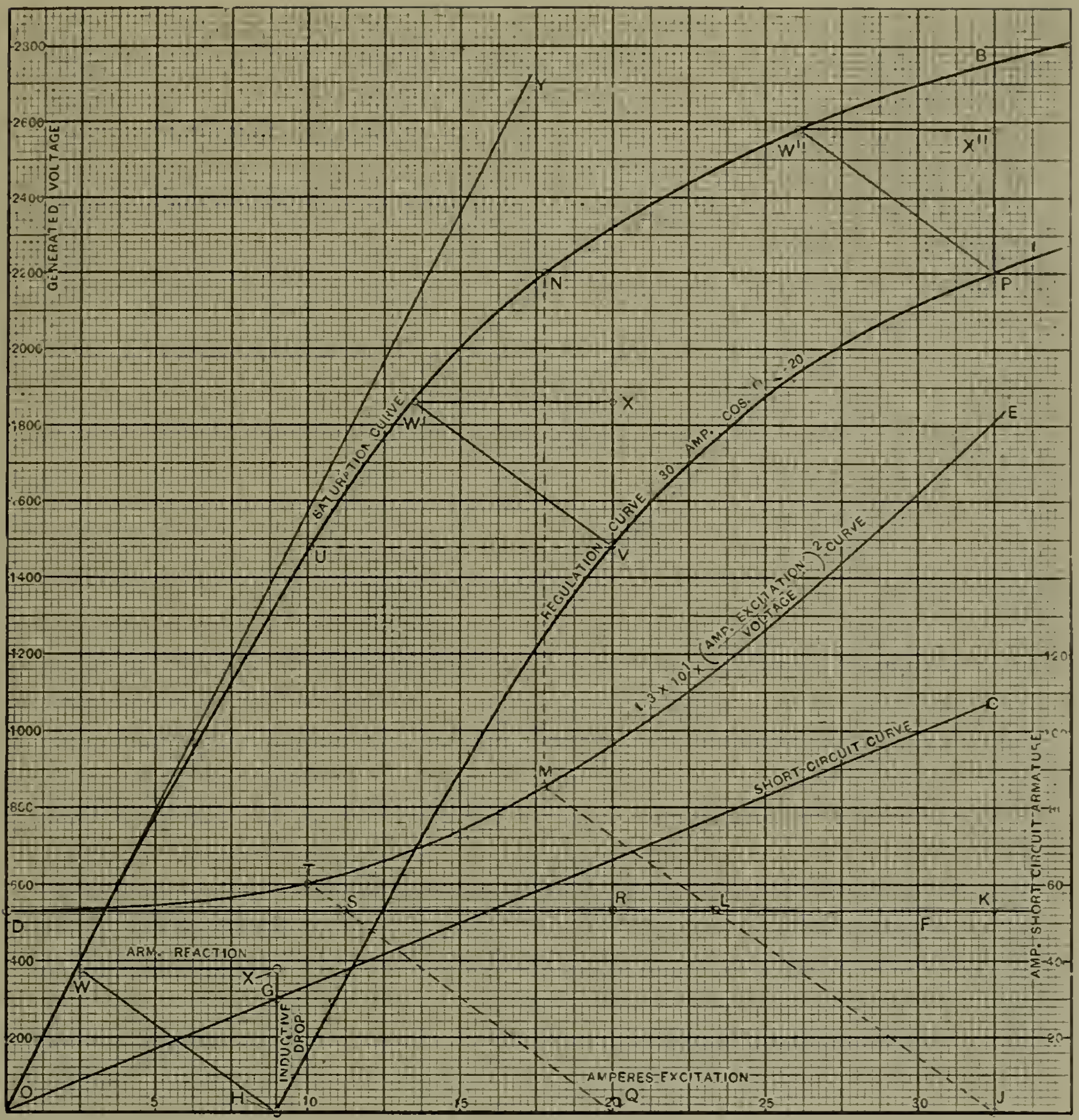


FIG. 1.—SATURATION AND REGULATION CURVES FOR A THREE-PHASE ALTERNATOR

that the ordinate for the zero excitation cannot be obtained from the saturation curve. Since, however, the ratio of amperes excitation and voltage for that point of the curve equals a similar ratio on the line OY, tangent to the saturation curve, we need only to calculate this ratio for any point on the line OY to obtain the ordinate of curve $DTME$ corresponding to zero excitation (point D). The ordinate of D, for instance, is

$$\left(\frac{15}{2350}\right)^2 \times 1.3 \times 10^7 = 530.$$

From point D, draw DSK parallel to the abscissæ. The four curves thus drawn form the basis for a graphical determination of the regulation curve on zero power-factor load, or, what is practically the same, on power factors smaller than 20 per cent.

The problem now arises to determine the voltage the generator would get with a variable excitation when loaded with its normal current of 30 amperes per phase.

On the short-circuit curve OC, we note the point G, which has the coordinates: 30 amperes armature current and 9 amperes excitation current. To get the voltage corresponding to $32\frac{1}{2}$ amperes excitation current (point J), 30 amperes per phase armature current, and zero power factor, we draw the line JX''. From its intersection K with line DS, mark off a distance KL equal to $OH = 9$ amperes. Draw the line JL, intersecting the curve $DTME$ at the point M. Draw from M a line parallel to the ordinate. It intersects the saturation curve at N; draw from N a parallel to the base, intersecting JX'' at P. Then PJ (2200 volts) is the voltage sought.

Repeating the operation for several exciting currents, yields the regulation curve $HVPI$ for 30 amperes armature current and practically 0 power factor (cos. ϕ < 0.20).

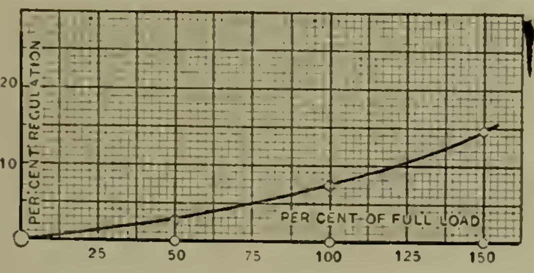


FIG. 2.—REGULATION, AT 100 PER CENT. POWER FACTOR LOAD, OF THE THREE-PHASE ALTERNATOR REFERRED TO IN FIG. 1

The drop in voltage, as indicated by the regulation curve, is due to the demagnetizing armature ampere-turns and to the inductive drop, which is practically equal to the impedance drop. The two components of the drop can be found by trial, if we keep in mind, first, that the armature reaction is at right angles to the inductive drop; second, that both remain practically constant for any excitation; and third, that the triangle thus formed describes the regulation curve by moving parallel to itself along the saturation curve.

In Fig. 1, WX was found to be the armature reaction in terms of the excitation current, and HX the inductive drop. By increasing the excitation current the triangle moves along the saturation curve, and takes positions as $W'X'V$ and $W''X''P$, in which $WX = W'X' = W''X''$, and $HX = VX' = PX''$.

Assuming, as usual, that neither the armature reaction nor the inductive drop is influenced by the power factor, we now are enabled to find the regulation on any power factor. Specifications generally call for the regulation on 100 per cent. and that on 85 per cent. power factor. Figs. 2, 3, 4, and 5 refer to these cases.

In Fig. 3 we have OX (equal to the armature reaction WX, $16\frac{1}{2}$ amperes, in Fig. 1) in phase with the terminal voltage OA, 2200 volts, obtained at no load with a current OQ, 17.75 amperes, leading by 90 degrees. The resistance drop AB is due to the load current, 30 amperes, and is in phase with OX. The resistance drop per phase is 0.6 ohm, and AB, therefore, equals $30 \times 0.6 \times 1.73 = 31$ volts. The inductive drop BC is at right angles with OX and equals HX, 380 volts, in Fig. 1. The resultant of OA, AB, and BC is OC, 2360 volts, the voltage induced in the armature.

From the saturation curve in Fig. 1, it will be seen that 2360 volts require 18.9 amperes excitation. The resultant field thus corresponds to 18.9 amperes excitation, and is represented in Fig. 3 by the vector OS, leading OC by 90 degrees.

Draw the circle $AFHK$ with OA as radius. Then HI represents the difference in voltage between the full-load and no-load conditions, with an excitation of NS amperes.

The regulation of an alternator is defined as the percentage rise in voltage upon throwing off the load, so in this case it is

$$\frac{OI - OH}{OH} = \frac{HI}{OH} = \frac{2360 - 2200}{2200}$$

$= 7\frac{1}{2}$ per cent.

The impedance pressure AC is proportional to the armature current ON. Thus for a current OM, which is half of ON, or for a current OP, which is one and a half times ON, the impedance voltage is one-half AC ($= AD$), and one and one-half AC ($= AE$), respectively. The induced pressures for these two loads are OD and OE, excited by the fields OR and PT, respectively. The currents carried in the field coils become MR and PT; the no-load pressures with these exciting currents would be OG and OL, the regulation $\frac{FG}{OF} = 2.7$ per cent., and $\frac{KL}{OK} = 14\frac{1}{2}$ per cent., respectively.

In Fig. 2 the regulation is plotted against the percentage of load carried by the alternator. The determination of the regulation on 85 per cent. power factor is made in the same way. Referring to Fig. 4, first plot the terminal pressure $OA = 2200$ volts, then the current vector ON = armature reaction, lagging behind OA by the angle ϕ, of which the cosine is 0.85. Next lay off the resistance drop AB parallel to ON, and the inductive drop BC at right angles to AB. Then OC is the induced voltage. The rest of the construction is exactly the same as on Fig. 3. Fig. 5 gives the regulation plotted against the per cent. of load.

This method of predetermination of the regulation suggested by Mr. Heyman applies as well for two-phase and single-phase alternators. The leakage coefficient is assumed constant for any load.

It will be noticed that the method here followed for the predetermination of the regulation differs considerably from that recommended in the Standardization Rules of the American Institute of Electrical Engineers. The latter gives values always far better than the actual regulation. (See "Experimental Basis for the Theory of the Regulation of Alternators," by B. A. Behrend. Trans. A. I. E. E., May 19, 1903.) According to the writer's experience, the way of calculation followed in this article yields very close results.

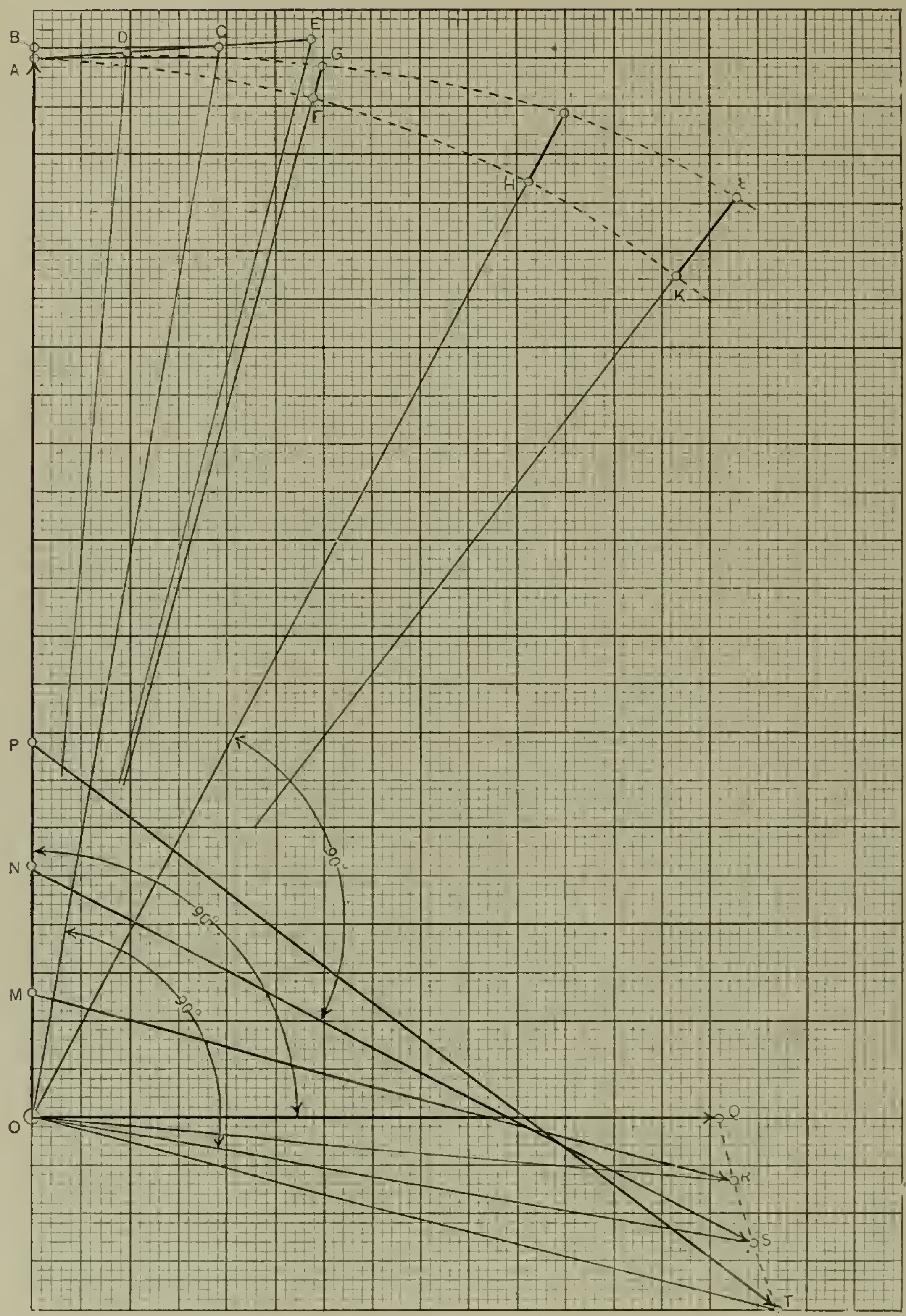


FIG. 3.—VECTOR DIAGRAM FOR 100 PER CENT. POWER FACTOR

THE EFFICIENCY TEST

The efficiency of an alternator, the rotor of which is mounted on two bearings independent of the prime-mover, is equal to the output divided by the sum of output, field copper loss, stator copper loss, iron loss, friction, and windage.

The efficiency of alternators, mounted differently from the preceding, equals the output divided by the sum of output, field copper loss, stator loss, copper loss, and iron loss. The friction and windage are considered as engine losses.

Among the first type of alternators are the belted and the water-wheel alternators. For lack of a better collective name, these will hereinafter be termed alternators of the double-bearing (D. B.) type. The second class includes the engine-type and the fly-wheel-type of alternators. They will be referred to as engine-type alternators. In general, the friction and windage losses are charged to the prime-mover, whenever the rotor is mounted on the prime-mover's shaft.

It is considered superfluous to explain how to measure the resistance of stator and rotor windings. Suffice it to say that in the case under consideration the stator resistance was found to be 0.6 ohms hot per phase winding, and the rotor resistance 3.2 ohms hot. It will be of more importance to discuss the following core-loss test, suggested to the writer by Bud. Frankenfield in an article on "Direct Measurement of Wattless Power."

In Fig. 6, representing the connection for the core-loss test, G, an alternating-current generator, supplies current to the three-phase windings *1*, *2*, *3* of the alternator under test, and runs it as a non-loaded synchronous motor. The capacity of G should be about one-tenth to one-fifteenth of the motor capacity, simply because it has to supply the no-load losses only. These consist of friction, windage, iron loss, and stator copper loss.

A voltmeter V is put across phase *1*, and the primary of a voltmeter-transformer T is connected across

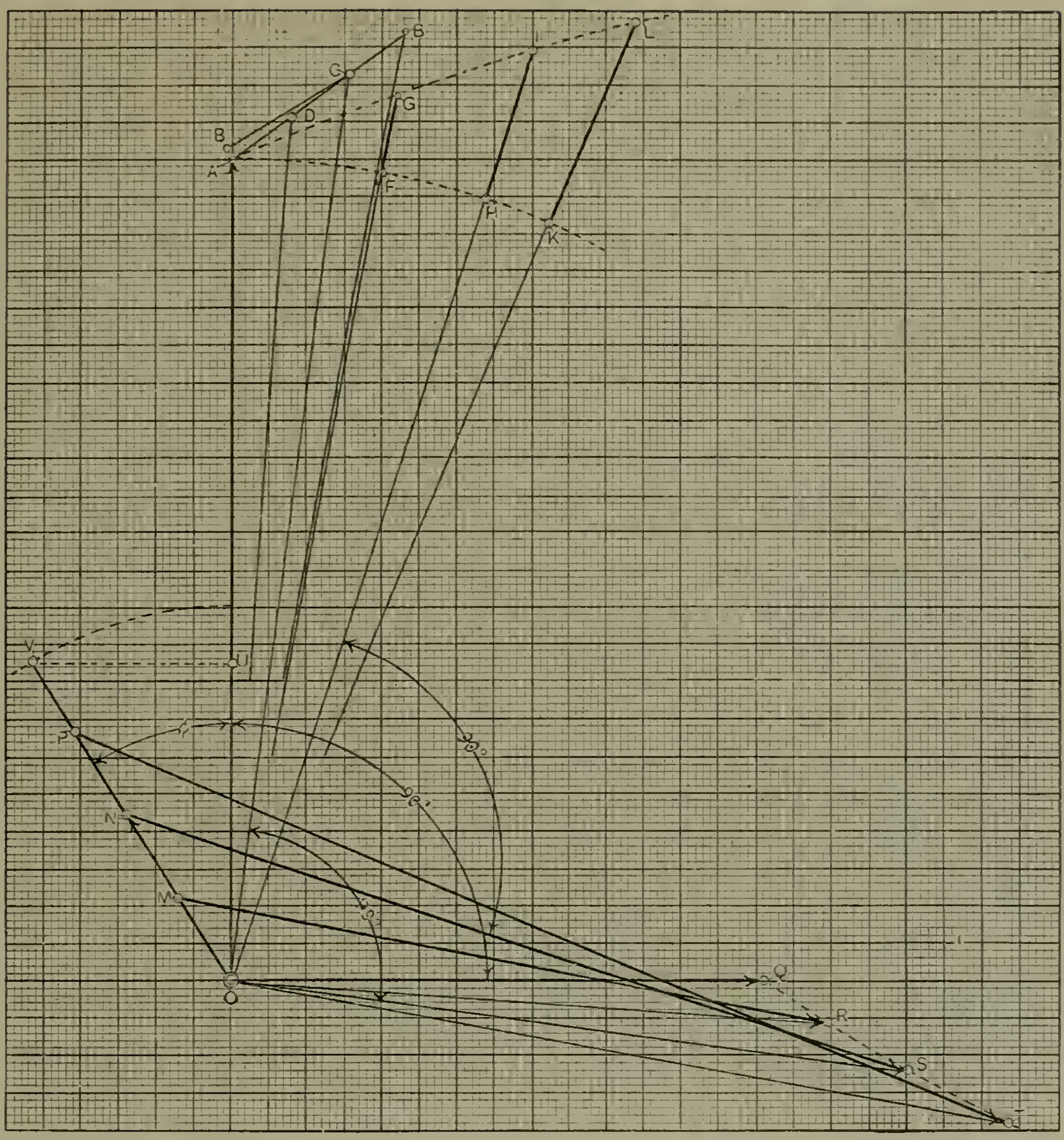


FIG. 4.—VECTOR DIAGRAM FOR 85 PER CENT. POWER FACTOR

phases 2 and 3, the secondary being connected to the fine-wire coil of a wattmeter *W*. The heavy-wire coil of the wattmeter is in series with phase *1*. Any current flowing through phase *1* can be brought into phase with the voltage across it by adjusting the field excitation. When both are in phase, the product of current and voltage represents the energy absorbed by the winding. Under these conditions, the terminal pressure may be assumed to equal the induced pressure. The error incurred by this assumption is smaller than the degree of accuracy of the instruments.

CORE-LOSS TEST.—TABLE I.

Volts per phase	1,590	1,270	954	636	318
Current per phase	1.41	1.38	1.44	1.76	3.07
Watts for three phases	6,730	5,230	4,120	3,360	2,930
Copper loss in stator	3.6	3.4	3.7	5.6	17
Iron loss, friction, wind	6,726.4	5,226.6	4,116.3	3,354.4	2,913
Terminal voltage	2,750	2,200	1,650	1,100	550

Fig. 6 shows that the phase difference between the pressure of the voltmeter-transformer and the pressure of phase *1* amounts to 90 degrees. Should thus the power-factor in phase *1* be 100 per cent., then the pressure of the voltmeter-transformer or the pressure applied on the wattmeter's potential coil will be at right angles with the current in the current coil of the wattmeter. The reading of the wattmeter will be zero. While adjusting the field excitation, the wattmeter is used exclusively to indicate when the power-factor is 100 per cent., i. e., when its pointer stands on zero.

To obtain the core-loss curve, the voltage applied on the three phases can be varied by varying the voltage of the generator *G*, Fig. 6. Table I. gives results of the test. The terminal voltage given in the table equals 1.73 times the voltage per phase. It will be noticed that the stator copper loss is very small, compared to the other losses. By neglecting it, the greatest error made would be $\frac{17}{2930} = 0.58$ per cent of the total loss and 0.015 per cent. of the capacity of the alternator, which is smaller than the degree of accuracy of the instruments.

In Fig. 7 the kilowatt iron loss, friction and windage is plotted as a function of the terminal pressure. The part drawn out in full represents that obtained from test. In general, the lowest voltage that can be applied on the alternator equals about one-fourth of the normal pressure. Below this the motor will come to a stop. With great accuracy, however, the points between one-fourth of normal pressure and zero voltage can be estimated by continuing the curve to the ordinate, as has been done by the dotted lines.

Since the speed remains constant throughout the whole range of voltages, the friction and windage remain constant, and at zero voltage the energy taken then equals the friction and windage loss. It is measured by the ordinate of the point *C*, and a line, drawn from *C* parallel to the abscissæ, represents the friction and windage loss at any pressure. Obviously, the iron loss curve is obtained by scaling the difference between the two curves just discussed.

Having separated the iron loss from the losses in friction and windage,

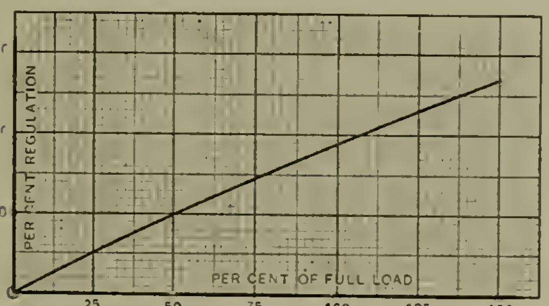


FIG. 5.—REGULATION, AT 85 PER CENT. POWER FACTOR LOAD, OF THE THREE-PHASE ALTERNATOR REFERRED TO IN FIG. 1

EFFICIENCY CALCULATION.—TABLE II.

115-K.W., 60-Cycle, 3-Phase Alternator 2200-Volt, 30 A-Phase, 900 R. P. M.

	COS. ϕ = 1.00			COS. ϕ = 0.85		
Amp. load per phase	15 *OM*	30 *ON*	45 *OP*	15 *OM*	30 *ON*	45 *OP*
Copper loss in stator	405	1,620	3,650	405	1,620	3,650
Amp. excitation	18.8 *MR*	20.8 *NS*	24.3 *PT*	21.8 *MR*	27.3 *NS*	33.8 *PT*
Copper loss in rotor	1,130	1,390	1,890	1,520	2,380	3,650
Induced pressure	2,220 *OD*	2,260 *OC*	2,320 *OE*	2,320 *OD*	2,440 *OC*	2,580 *OF*
Iron loss	2,500	2,580	2,720	2,720	3,000	3,400
Friction and windage	2,800	2,800	2,800	2,800	2,800	2,800
Total loss { Eng. type	4,035	5,590	8,260	4,645	7,000	10,700
Total loss { D. B. type	6,835	8,390	11,060	7,445	9,800	13,500
Output	57,500	115,000	172,500	48,875	97,750	146,625
Input { D. B. type	64,335	123,390	183,560	56,320	107,550	160,125
Input { Eng. type	61,535	120,590	180,760	53,520	104,750	157,325
Efficiency { Eng. type	93.5	95.37	95.43	91.1	93.3	93.2
Efficiency { D. B. type	89.4	93.20	94.00	86.8	90.9	91.6

Note.—Stator resistance per phase = 0.6 ohms hot. Field resistance = 3.2 ohms hot. For *OM*, *MR*, *OD*, etc., see Fig. 2 and Fig. 4.

we can proceed to calculate the efficiency of the motor run as an alternator. The diagrams in Figs. 2 and 3 form the basis of the calculation, which is carried out in Table II.

Given the load, the stator copper loss becomes known. On the vector diagram the excitation current for that load is scaled, and the field copper loss is obtained. The induced pressure, measured on the vector diagram, gives the iron, friction and windage losses by reference to Fig. 7.

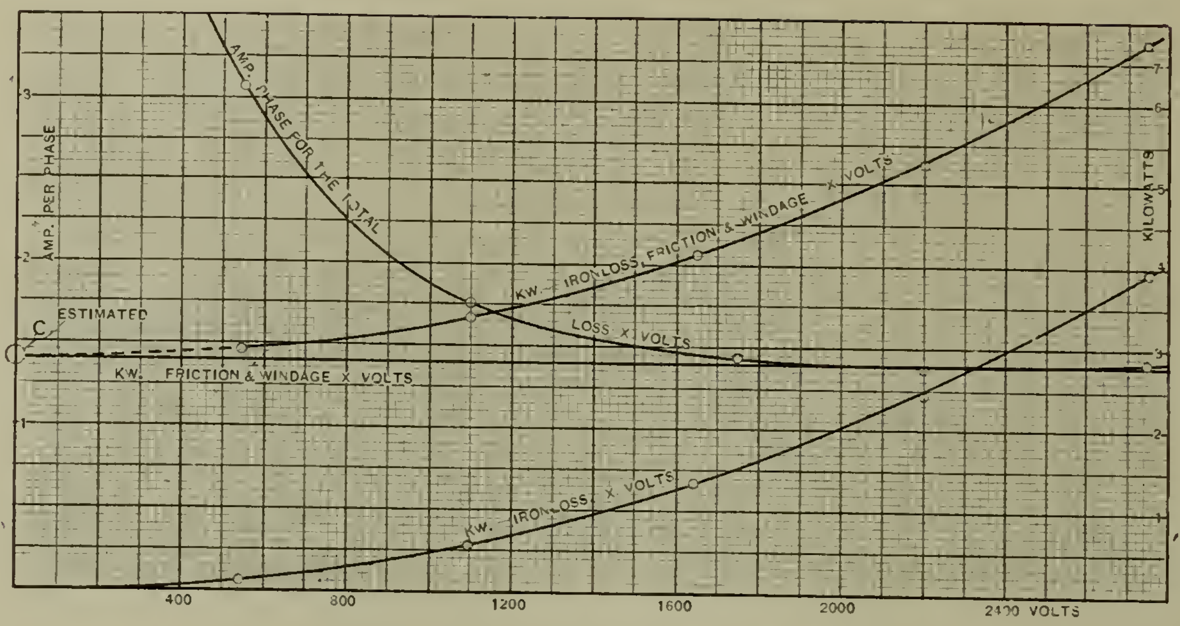


FIG. 7.—CURVES OF IRON, FRICTION AND WINDAGE LOSS

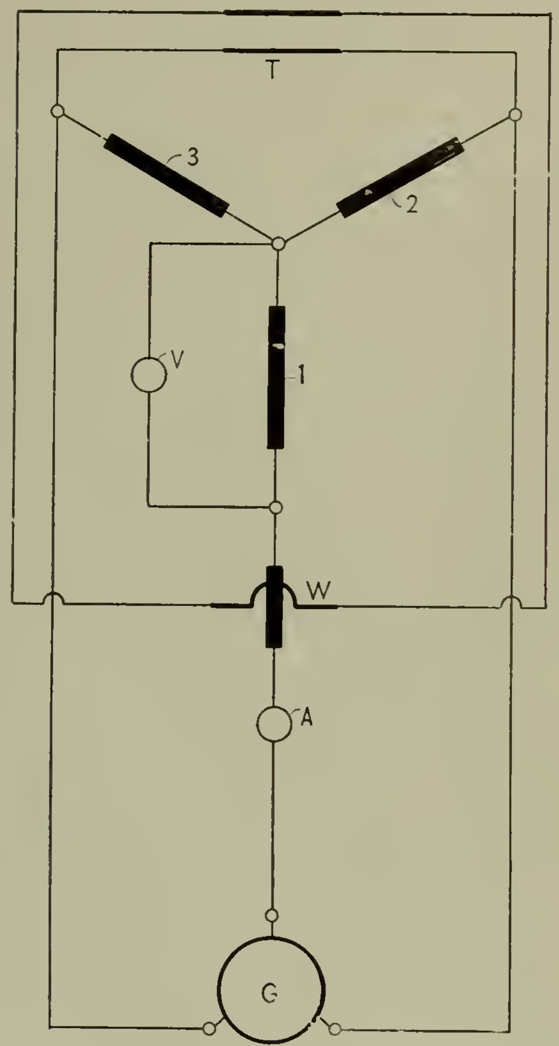


FIG. 6.—CONNECTIONS FOR A CORE LOSS TEST

The efficiency has been computed for the alternator both as an engine-type and as a double-bearing-type generator. The results of the computations of the regulation and the efficiency have been embodied in the performance diagram in Fig. 8.

International Electro-Technical Commission

IN September, 1904, towards the close of the International Electrical Congress at St. Louis, a resolution was unanimously adopted by the chamber of government delegates that steps should be taken to secure the co-operation of the technical societies of the world by the appointment of a representative commission to consider the question of the standardization of the nomenclature and ratings of electrical apparatus and machinery. The president of the American Institute of Electrical Engineers was asked to take charge of the matter in the United States, and Colonel Crompton was appointed to deal with the countries on the other side of the water. A preliminary meeting was held at the Hotel Cecil, in London, on Tuesday, June 26, with Alexander Siemens in the chair. At this meeting Lord Kelvin was unanimously elected the first president of the commission, and Colonel Crompton was appointed honorary secretary.

It is intended that the work of the commission shall proceed by correspondence, and that the efforts of the commission will be addressed, in the first instance, to the standardization of nomenclature, so that the electro-technical terms used shall be common to all countries, and it is hoped then that a similar standardization of physical formulæ, which must be equally common to all countries, may be reached.

F. B. Crocker, A. E. Kennelly, and C. O. Mailloux represent the American Institute of Electrical Engineers.

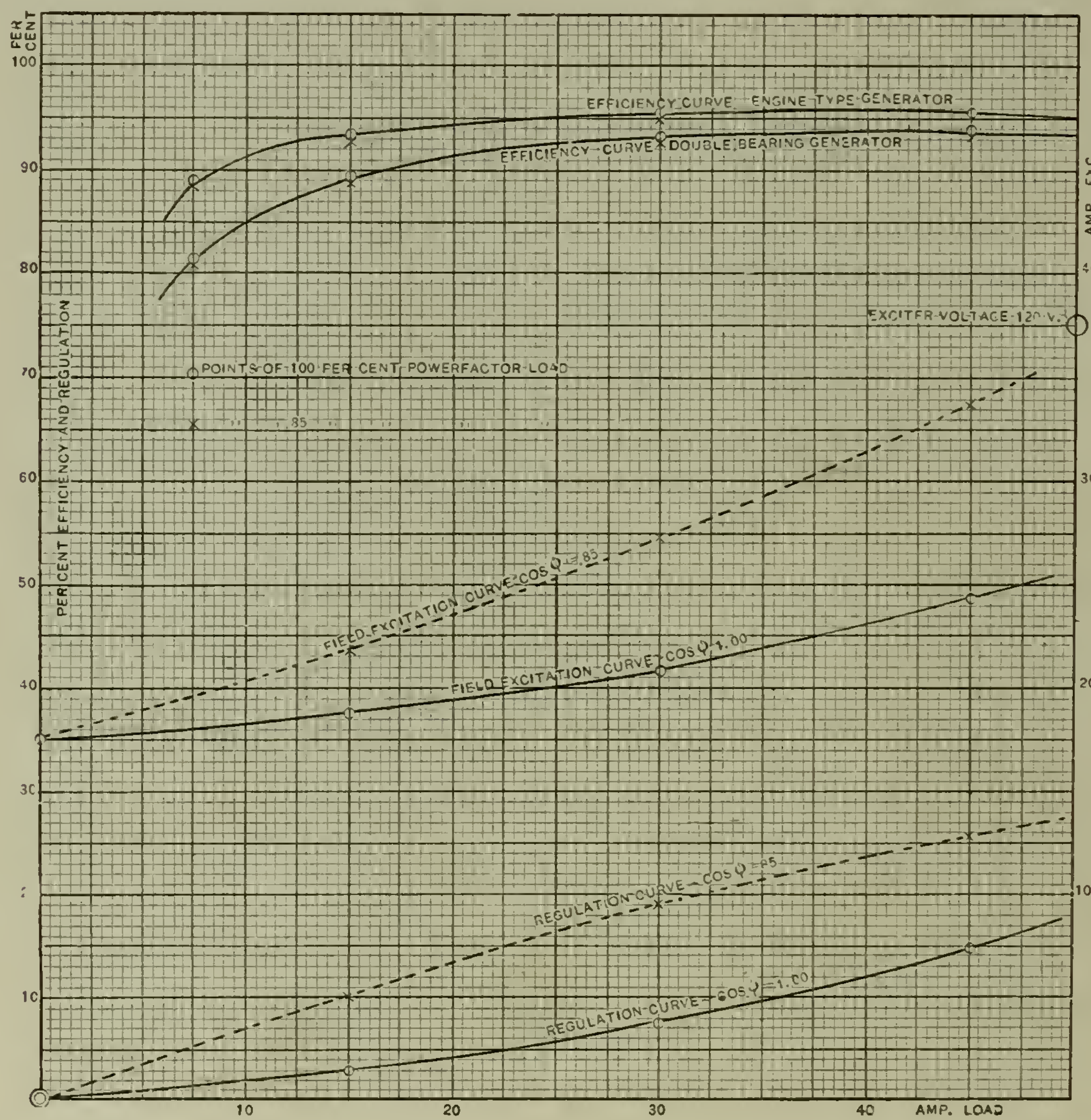


FIG. 8.—PERFORMANCE DIAGRAM OF THE THREE-PHASE ALTERNATOR REFERRED TO IN FIG. I

The Electric Car Equipment of the Long Island Railroad

By W. N. SMITH

FIG. I.—A STEEL MOTOR CAR FOR THE LONG ISLAND RAILROAD, BUILT AT THE BERWICK (PA.) SHOPS OF THE AMERICAN CAR & FOUNDRY COMPANY

GENERAL TRAFFIC CONDITIONS

THE tendency of a change from steam to electric motive power on suburban lines such as those of the Long Island Railroad, is to convert them into a rapid-transit system of the same general type as the subway and elevated systems now operating in the largest cities. The building up of any suburban territory is dependent upon the transportation facilities provided for it, and the inevitable result of improvement in transportation is to increase the traffic to a degree gradually approaching the density prevailing on metropolitan rapid-transit lines.

FIG. 2.—AN ELECTRIC EXPRESS CAR

Frequency and regularity of service are essential to the profitable development of a rapid-transit system. The car service must also be of a sufficiently flexible character to meet the fluctuating conditions of the traffic, which are changing from hour to hour during the day, as well as from day to day and month to month.

The now well-known multiple-unit system of train operation, which has been so satisfactorily tested in elevated and underground railway service, is, obviously, also the best method for the convenient handling of the suburban type of train, where, as in other rapid-transit service, relatively frequent stops are necessary. The distribution of motive power through the train eliminates dead weight, and, at the same time, utilizes the weight of the train itself to secure the adhesion needed for train propulsion, an advantage which becomes of greater relative importance as the interval between stops is shortened and the train is accelerated from rest more frequently, which is a condition peculiar to rapid-transit and suburban passenger service. Argument is no longer needed to demonstrate the advantages of this type of train equipment; the problems are simply those of mechanical practicability, sufficiency and reliability.

The design of the car equipment of the Long Island Railroad is based upon a careful study of the traffic conditions as they were outlined by the railroad officials at the commencement of the undertaking, calling for trains with the number of cars varying from two to six per train at different hours of the day, in regular operation, while heavy excursion travel to the beaches and race tracks would occasionally require trains of ten or twelve cars. Some of the service is express and some local. It was deemed of the greatest importance to provide a single type of equipment that should be uniformly available for all the varying conditions of train service.

The proposed local service on the Atlantic Division involved making

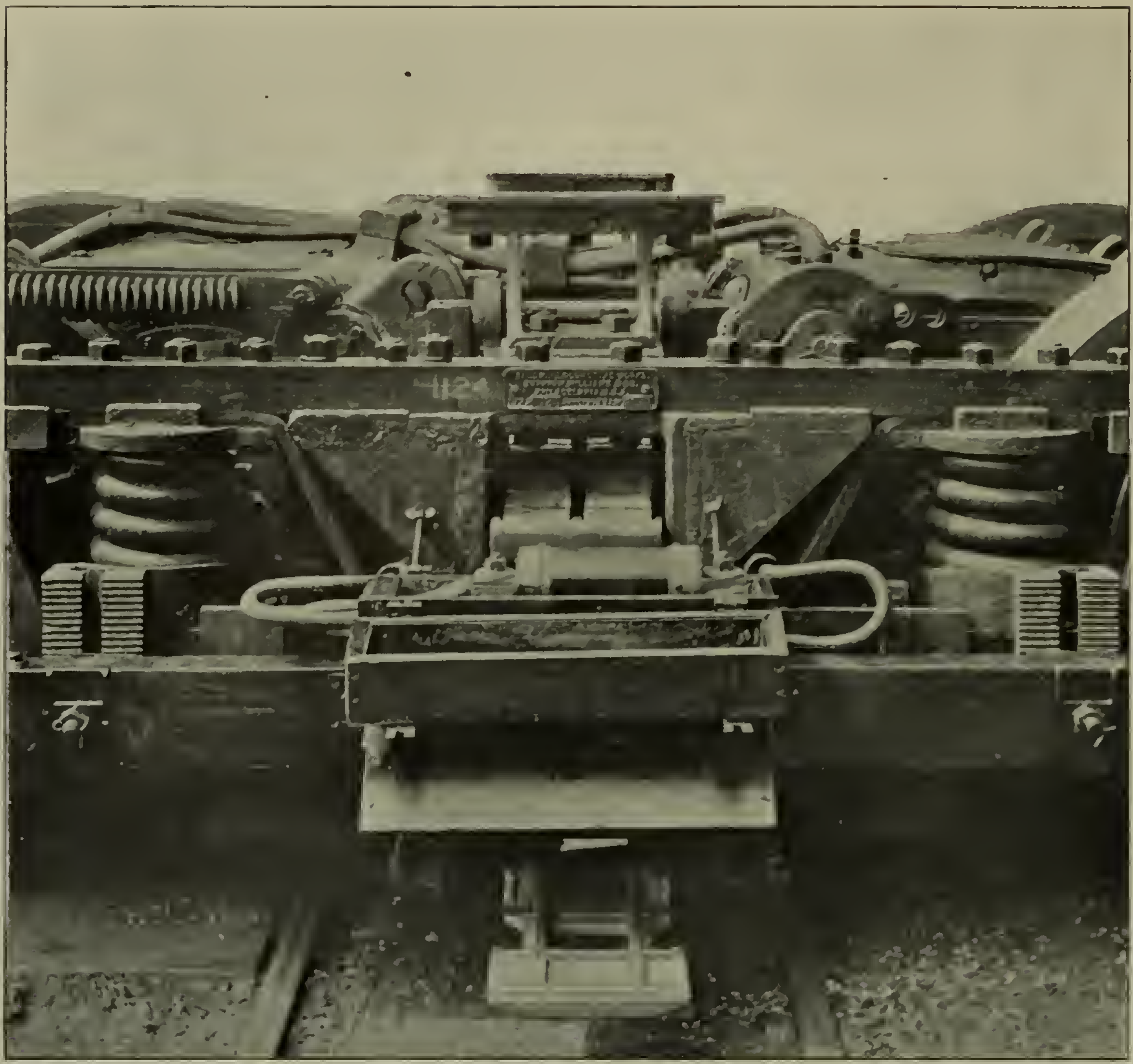


FIG. 3.—THE THIRD-RAIL SHOE, FUSE, AND CONNECTIONS

stops at an average of about 1.6 miles. The express service originally contemplated between Flatbush Avenue Station and Jamaica provided for only one intermediate stop in the 9.63 miles between them. On the Rockaway Beach Division, a local train making all stops between Flatbush Avenue and Rockaway Park would average one stop every 0.99 mile, while an express run to Rockaway Park involved a run 7 miles in length at the highest practicable speed.

These runs called for a schedule speed, including stops, of about 25 miles per hour for local trains on the Atlantic Division, and about $30\frac{1}{2}$ miles per hour for the express trains. Upon the Rockaway Beach Division, with relatively more frequent stops, the local run called for a schedule speed of about 20 miles per hour, while the express run, with seven stops in the 15.86 miles, called for about 25 miles per hour. The average length of stop was usually assumed at 30 seconds.

The headway of trains on the proposed schedule was, between Flatbush Avenue and Jamaica, about 20 minutes during the greater part of the day, with 10 minutes during the morning and evening rush hours, and 30 to 60 minutes during the early morning hours. During the rush hours express trains were also to be interspersed with locals.

Between Flatbush Avenue and Rockaway Park the local trains were to run on about half-hourly headway during the most of the day, this being decreased to 20 minutes during the rush hours, and 60 minutes during early morning hours. Express trains were also to be interspersed between locals during the rush hours. The Brooklyn Rapid Transit trains operating over parts of the Long Island lines were to be mostly express, running on about half-hourly intervals during the early part of the day, but from noon until late at night on 15-minute headway.

On days when there would be both a race-track movement on the Atlantic Division and heavy travel to the beaches, the headway of the combined traffic on Atlantic Avenue was to be reduced to about $3\frac{1}{3}$ minutes.

The Long Island Railroad local trains as originally proposed were to consist of two and three cars, except during the rush hours, when they were to be of six cars. The express trains were to consist of three cars each. The Brooklyn Rapid Transit trains on ordinary days were to be of four cars each, increased to six on holidays.

The maximum possible speed for express runs can be made when all the cars of a multiple-unit train are motor cars. Ordinary schedule conditions, however, usually permit a portion of each train to consist of trailers, and the most severe condition of frequent stops can be met if the proportion of trailers is not more than one trailer to two motor cars. A considerable saving in the weight of the entire train is thus possible without exceeding either the tractive power of the motors or their ability to radiate the heat developed by the frequent accelerations which are the severest tax upon their capacity. In fact, the proportion of motor cars to trailers is based upon the speed and time characteristics of the schedule and the frequency of stops.

The fact that the Atlantic Division is partly in a subway, and the need for interchangeability with the rolling stock of the Interborough Rapid Transit subway, has much to do with the design of the cars. The complete success of the first all-steel passenger cars ever built, which were designed by George Gibbs for the New York Subway, led him, in his capacity as chief engineer of the Long Island Railroad electric conversion, to advocate their use on this road as well. To the Interborough Rapid Transit Company and the Long Island Railroad Company belong, therefore, the distinction of being the first railroads in the world to adopt this radical departure in car construction, thus insuring to the public complete immunity from the danger of fire in cars equipped with apparatus carrying powerful electric currents.

The incidental advantages of these steel cars over wooden cars in superior strength and durability are, of course, likewise of importance in insuring their adoption. As the Long Island Railroad cars were obliged to meet very similar conditions, both as to the physical nature of the route to be traversed and the class of travel to be handled, they were built along practically the same lines as the above-mentioned steel cars for the New York subway. In fact, except for the steps, which are made necessary by the low platforms at stations in the suburban districts, the steel car bodies are practically identical with those designed for the New York subway.

It has been common practice in the past to build passenger coaches for rapid-transit service of rather lighter construction than the standard steam railway coaches, chiefly because the steam locomotive was universally used and it was desired to keep down to a minimum the weight behind the locomotive. The multiple-unit system of control, however, which allows the distribution of the motive power under all the cars, removes this restriction upon the weight and makes it possible to construct the parts of a suburban passenger car with more regard for rigidity, and greater ability to resist shocks. Multiple-unit cars for this kind of service can, therefore, be made as substantial as the requirements of safety and durability demand, but it should also be noted that the steel construction adopted does not materially increase the weight over what would be called durable construction in a wooden car, the increased strength and durability being secured without sacrificing operating economy.

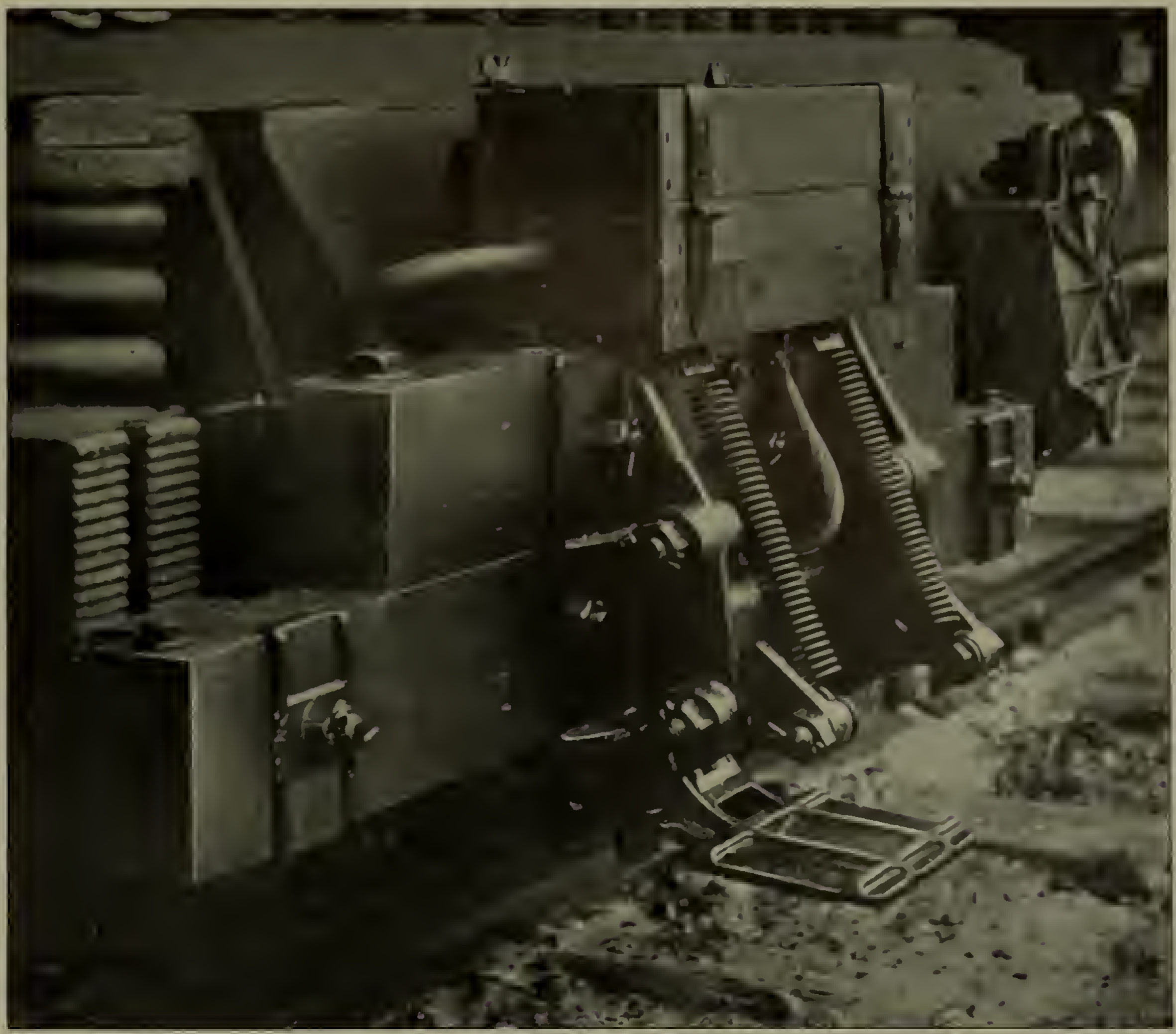


FIG. 4.—INNER POSITION OF THE ADJUSTABLE THIRD-RAIL SHOE

CAR BODIES

The principal dimensions of the steel trailer cars are the same as those for motor cars, and they may, if desired, be readily converted into motor cars. While the conformation of the car body is practically identical with the conventional type of steam railroad coach, the adoption of steel as the constructive material is responsible for some differences in the general design of car framing that have been hitherto followed in wooden car construction. These differences will appear in the course of the description. Most of the standard parts in the framing of the wooden cars have their counterparts in the framing of the steel car.

VESTIBULES

The vestibules are of the Gibbs patent type with floors of steel plates. The vestibule side doors are arranged to slide in pockets in the sides of the car, leaving the entire platform to the passengers. These doors close against pneumatic cushions, so as to readily release the clothing of passengers if caught by the closing of the door. The device for operating the side doors consists of a series of bell cranks and levers so arranged that the movable parts are either overhead in the vestibule or entirely outside of it, leaving the entire interior of the vestibule clear. The side doors are operated by brakemen standing outside of the doors at the extreme end of the vestibule.

FIG. 5.—OUTER POSITION OF THE ADJUSTABLE THIRD-RAIL SHOE

Side steps are provided with plain wooden treads, the gangway being fitted with trap doors of 3-16-inch sheet steel, to enable the use of the entire width of the vestibule when the side doors are closed. When in the extreme open position the vestibule end door is folded over the master controller, the brake valve, and all other apparatus in the motorman's compartment. The upper half of this door is glazed, like the others. When this door is shut, and the side doors closed, the entire vestibule is available as a motorman's compartment, and the control apparatus is then entirely exposed. A view of

FIG. 6.—A CAM IN THE THIRD RAIL FOR CHANGING THE POSITION OF THE SHOE

the vestibule under these conditions is shown in Fig. 7.

The body end doors are of the double sliding type, and are fitted with a door coupling device that will hold them in any desired position to prevent them from closing when trains are rounding curves. Marker lamps are mounted on the hood over the vestibule platforms and are operated from inside of the vestibule by handles extending through the canopy sheathing. These handles are fitted at the lower end with discs carrying coloured crystals that correspond to the colour of the lenses on the four sides of the marker lamps.

In the vestibule at the motor end of the car, just forward of the end door pocket on the left-hand side facing outward, is placed a swinging door, made convex, of pressed steel, so as to form a pocket to contain the auxiliary control switchboard panel, which will be described later.

All motor cars are equipped with pilots suspended from the platform buffers, and the vestibules are fitted with pantagraph safety gates and guard chains to prevent trainmen and passengers from falling between the cars. The usual grab handles are also fitted to the sides and ends of the vestibules. An air whistle is also provided over each vestibule, with its operating valve situated conveniently to the control apparatus. Wooden paddles are carried in the vestibules of all cars, to be used to raise the contact shoes from the conductor rail when necessary.

FINISH

The flooring of the car body is of corrugated sheet iron, and is supported by the longitudinal sills and the steel plate bridging that is riveted across the space between the sills. Metal clips are riveted to the sheets at about 10-inch centres, to secure the "Monolith" plastic floor upon which, after being finished, the maple floor strips are laid with brass screws. This monolithic floor is absolutely fireproof, and is laid on in the form of a cement, which, when set, has smooth, hard finish.

The interior of the car is attractively finished in green and gold, the hardware fittings being of lacquered bronze. Seats for fifty-two persons are provided in each car, the arrangement being similar to that used in subway and elevated railway cars generally. Steel construction is also employed for the seat frames, the cushion and seat backs being of rattan. Strap rails of polished mahogany are also provided, running along each side of the car in the clere story, supported in bronze brackets. The wainscoting is of steel, backed by asbestos "ceilinite," so as to make it conduct heat less readily.

There are 130 motor cars and 4 trailers, all of which were built at the Berwick, Pa., shops of the American Car & Foundry Company. They were personally designed by George Gibbs, chief engineer of electric traction of the Long Island Railroad, and a number of United States and foreign patents have been issued to him covering the various features of their construction. Fig. 1, on page 199, is a view of the completely equipped steel car, showing the vestibule end door closed, as it appears when the vestibule is being used as the motorman's compartment.

THIRD-RAIL SHOES

The hinged slipper-type of third-rail shoe is used on the Long Island cars, supported on the usual wooden beam, which is clamped against the notched face of the equalizer spring seat castings, providing means for vertical adjustment. Upon the centre of the beam is placed a 600-ampere enclosed type fuse in a wooden box, with a hinged cover and lined with asbestos. The arrangement is shown in detail in Fig. 3.

Trains from the Brooklyn Rapid Transit Company's elevated lines operate over the Atlantic Avenue and Rockaway Beach Divisions by way of Chestnut Street Junction to Rockaway Park. The Brooklyn elevated lines have been for some years operated by the third rail, but the location of their rail is 22¼ inches outside and 6 inches above the track rail, while the Long Island Railroad third rail is 26 inches out and 3½ inches up. This made it necessary to devise some form of adjustable third-rail shoe which would operate with equal facility over both third rails and be able to change from one to the other at reduced speed without requiring attention on the part of the motormen or train crew. Such an arrangement has been worked out, and patents on it have been applied for by James C. Boyd.

It consists essentially of a hinged slipper type of shoe mounted upon a movable lug, which is held in either position by means of coil springs, and is actuated by an arm that engages with a stationary cam mounted alongside of the track, in line with the third rail. The movement of the car past this cam in one direction changes the shoe from the inner to the outer low position, while a reverse movement of the car past the cam changes it from the outer to the inner raised position. The shoe in the inner position is shown in Fig. 4, while in the outer position it is shown in Fig. 5. The cam as it appears in the third rail is shown in Fig. 6. These adjustable shoe equipments have been fitted to such cars of the Brooklyn Rapid Transit Company as are to operate over the lines of the Long Island Railroad.

ELECTRICAL EQUIPMENT

The selection of the electrical equipment of the motor cars, whether operated singly or in trains, required the most careful study of the loads to be handled, the schedule conditions under which the apparatus is to be operated, and the limitations of the apparatus itself. Whether all cars of a train should be motor cars; whether all axles of the motor cars should be equipped; what the motor charcteristics, the ratio of gearing, and the wheel diameter should be; the maximum speed that could be depended upon to make up time, and the amount of time to be allowed for "laying over" at terminals,—these, among others, were considerations of the utmost importance in coming to a decision on the equipment that would most economically serve the purposes of the Long Island Railroad suburban lines.

The variable number of motor and trailer cars per train caused some variation in the load per motor on different trains. There were also various classes of express and local service to deal with, involving different schedule speeds and average lengths of runs between stops, for all of which it was desirable to provide a uniform equipment, so that any car could be devoted to any desired type of service without discrimination. The motor equipment to be adopted must handle traffic efficiently under any and all of the varying conditions of train weight and schedule speed that occur in the operation of the suburban lines of the Long Island Railroad.

Careful investigation showed that the greatest flexibility would result from a two-motor car equipment, using the most powerful motors practicable. The limitations were mainly the dimensions imposed by the largest trucks that could be operated under the conditions prescribed by the tunnel and curve clearances, which restricted the wheel base of the motor truck to 6 feet 6 inches. This restricted the size of the motor to about 200 H. P., and the study of the conditions was consequently reduced to an examination of the characteristics and gear ratio most suitable for this motor, and of its power of endurance to resist overheating.

At the outset, a series of speed tests was made on various steam trains, in order to compare the actual running time with that laid down in the time tables, and with the times which the railroad officials desired to be met by the electrical equipment. An ordinary passenger coach was fitted up with speed-recording devices and a number of speed curves were obtained.

FIG. 7.—VESTIBULE OF STEEL MOTOR CAR

The best performance of a relatively light steam locomotive train weighing 171.9 tons with the locomotive is shown in Fig. 8. The difference in the running time of an equivalent electric train is shown in the same diagram, and, in general, indicates that for all average lengths of run between stops in suburban service up to about two miles the electric train is the faster.

The average length of run over the Atlantic Division, the first to be equipped, was originally estimated at 1.6 miles, but in practical operation since the road was equipped this has been reduced to about 1 mile, giving the electric trains a still greater advantage in speed, due, of course, to their higher rate of acceleration.

These same tests also threw some light on the time to be allowed for various delays to which the trains were likely to be subjected, and, together with the actually derived speed curves, and calculated best-performance curves, showed the relation between the schedule time ordinarily allowed for a train on a given run, and the best time that it could possibly make over the same distance.

An idea of the scope of the problem may be had from the statement that there had to be compared about twenty-three different types of train runs, local and express, on eight different routes, with the average distance between stops different in practically every case.

The general solution of the problem was worked out by the aid of speed-time curves, whose value for this purpose began to be recognized when electrical rapid transit problems first began to come up for solution on a large scale in connection with elevated railways. The general type of curve referred to is that illustrated in Fig. 9, which has the advantage of showing the instantaneous fluctuations of the current applied per motor, or for an entire train; and from this record of current fluctuation with regard to time the average output in watts and the total power in watt-hours is easily computed. The various quantities of speed, time, distance and power, a knowledge of whose relations is desired, are readily worked out from such curves.

This is hardly the place to give a detailed account of the development of speed-time curves, that subject having been already fully covered in professional papers and technical articles. It should be said, however, that speed-time curves require special assumptions, first as to train weight, and the train resistance due to grades, curves, rail, journal and air friction, which go to make up the total resistance to be overcome; and, secondly, the speed and torque characteristics of the motor and the average voltage during operation, which determine the power that is available to overcome resistance; and, finally, the retarding effects of coasting and braking, which are equally important. The resultants of these forces

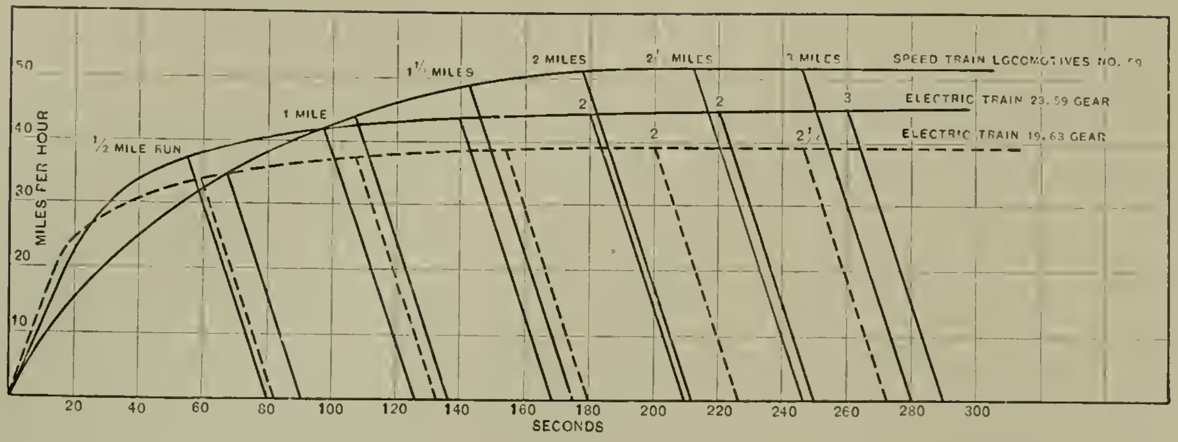


FIG. 8.—TIME SPEED CURVE OF A STEAM TRAIN WEIGHING 171.9 TONS, DISREGARDING A SMALL LIVE LOAD; AND TIME SPEED CURVES OF PROPOSED ELECTRIC TRAINS, WEIGHING 121 TONS WITH STARTING LOAD. ALL TRAINS HAD THREE CARS

express themselves in the variation of the speed of a train from rest to full speed and back again to rest, which is plotted for computation and for general comparisons, in the speed-time curves.

It will be seen by the foregoing statement of the conditions to be met and the results sought, that the problem involves a large number of variable quantities, each of which has important influence upon the result. In the last analysis, the solution of the problem is reduced to the selection of the gear ratio which will enable a given motor to handle without overheating a given range of tonnage over a given range of schedule speed between stops, with proper allowance for difference in the average length of run between stops.

Considerable work was done in the early stages, in comparing results previously obtained by former experimenters with a view to determining the train resistance, which had to be properly assumed in order to compute the speed of trains, and the power required by them. With this data secured, the next step was to determine, first, the schedule speeds that could be maintained by certain motor and train combinations; second, the heating effect upon the motors when run continuously through the cycles of operation representing the average length of run, and the minimum permissible lay-over at the end of a run, for trains in continuous operation; and third, the power consumption of the system, with average and maximum service.

The schedule speeds were derived directly from the speed-time curves. The most rational method available for estimating the heating effect developed in each motor was to compute the "square root of the mean square" current per motor averaged over the entire time of any given run, or succession of runs, and to compare it with the limiting value set by the manufacturers for the motor selected. The power consumption was easily computed from the current-time curve corresponding to each speed-time curve. The time distance curve was used to determine the location of the amount of current at any instant, thus enabling the ready computation of third-rail and track drop, and the distribution of load between sub-stations. Fig. 7 gives each of these curves for a typical run of a three-car multiple-unit train.

These graphical methods of solution, based upon speed time curves, were found to be of the greatest possible utility, as by means of them it became possible to determine not only the powering of the trains and the limits of heat endurance of motors of known characteristics, but also the loading upon the sub-stations, the drop in the third-rail and track circuits, and the loading upon the power station at any instant for a given train schedule covering the entire system.

The work of determining the equipment of any system, particularly one so extensive and interconnected as that of the Long Island Railroad, begins with the railway motor performance as the principal starting point, and when the train requirements have been worked out carefully, the determination of the rest of the equipment is a matter of detailed computation. The general fitness for its work of the equipment actually selected, as proved by the operating results, has justified the care that was taken to work out the problem in a consistent and logical manner.

The general result of the motor computations, as determining the size of the car equipment, was that a medium gear ratio (25.58 for the No. 113 Westinghouse motor) was fixed upon and the number of motor cars and trailers per train was recommended in accordance with the following table:—

Length of Train.	Local	Express
2-Car train.	2 Motor cars. No trailers.	1 Motor car. 1 Trailer.
3-Car train.	2 Motor cars. 1 Trailer.	2 Motor cars. 1 Trailer.
4-Car train.	3 Motor cars. 1Trailer.	2 Motor cars. 2 Trailers.
5-Car train.	3 Motor cars. 3 Trailers.	3 Motor cars. 2 Trailers.
6-Car train.	4 Motor cars. 2 Trailers.	3 Motor cars. 3 Trailers.
7-Car train.	4 Motor cars. 3 Trailers.	4 Motor cars. 3 Trailers.
8-Car train.	5 Motor cars. 3 Trailers.	4 Motor cars. 4 Trailers.

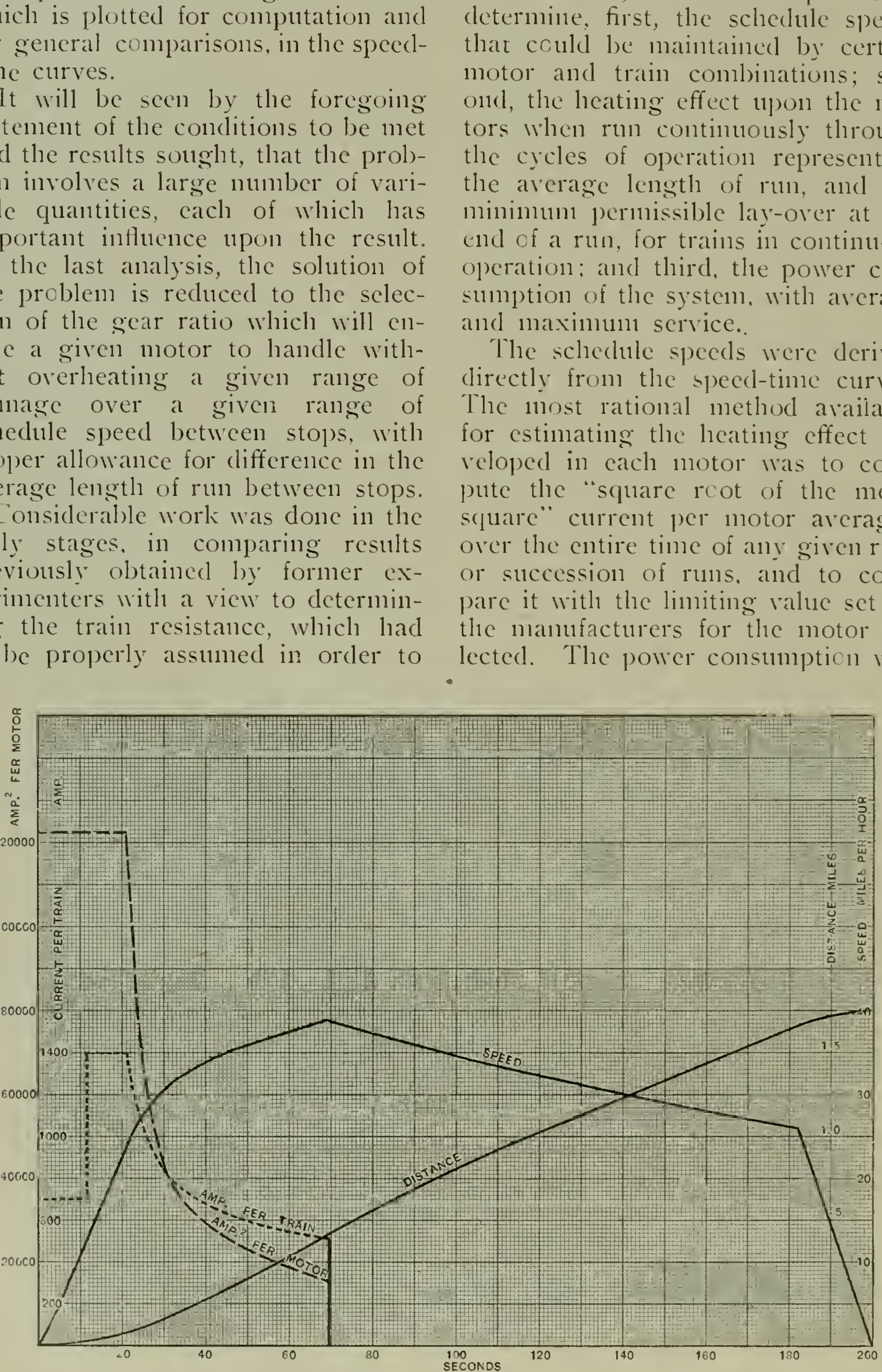


FIG. 9.—TYPICAL SPEED TIME CURVE OF A 117-TON TRAIN

MOTORS

The motors are of the Westinghouse type, both mounted on one truck. As may be seen in Fig. 11, the cast-steel frame is split at an angle of 45 degrees horizontally, the axle bearing being in the lower half. By lifting off the top half of the frame, the armature can be taken out without removing the motor from the truck, or the motor can be lifted entire from the truck by removing the gear case and axle caps. Access to the brushes and brush-holders is provided through the opening in the frame over the commutator, which extends down well over the axle, that it approaches the waste from below and is filtered by it before reaching the bearings. The reservoirs are easily accessible, and oil can be readily kept at the proper level.

The axle bearings are made of split bushings of phosphor bronze lined with babbitt, and are secured position of the cars, to meet the exigencies of traffic.

The Westinghouse electro-pneumatic multiple control system was adopted for the cars of the Long Island Railroad, its special features being air operation of main switches, the use of storage battery current for

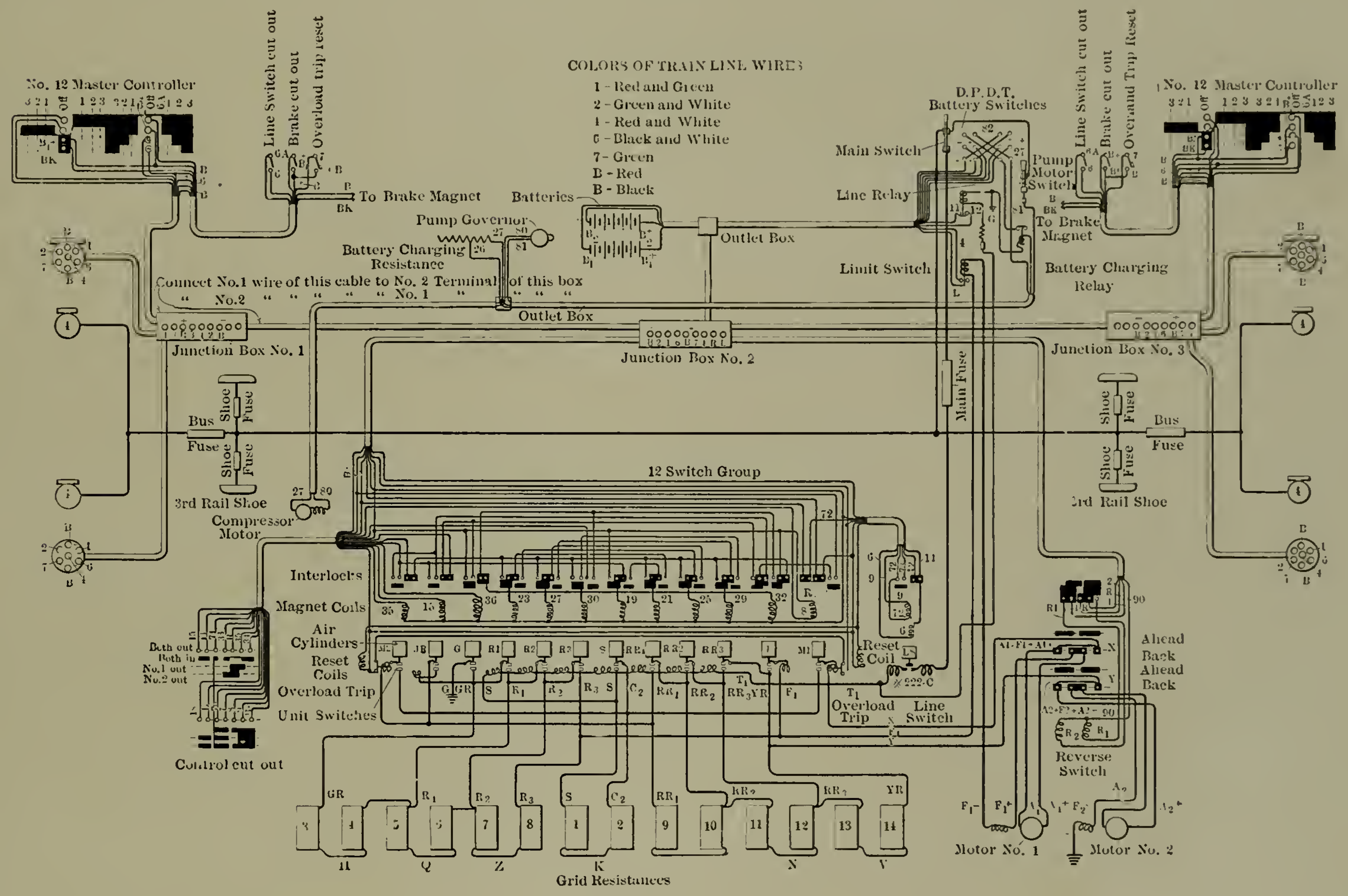


FIG. 10.—WIRING DIAGRAM OF A MOTOR CAR

making it easy to inspect the motor from the pit. The commutator cover is perforated, and openings in the bearing housings at the pinion end provide for ventilation, which is practically effected by air being drawn in at that end and thrown out through the ventilating cover over the commutator, forming a continuous draught through the motor.

The armature bearings are solid phosphor bronze bushings, lined with 3-32-inch babbitt metal, so that in case of a bearing becoming overheated during service, even though the babbitt should melt out, the armature is supported by the bronze bushing, which is an excellent bearing surface, and will prevent the armature from rubbing on the poles. All the bearings are arranged for oil and waste lubrication, oil being fed into the reservoirs through openings separate from the waste pockets, so to the lower half of the lower frame by axle caps and heavy stud bolts.

CONTROL SYSTEM

One of the most important features in electric railway development during the past eight years has been the gradual perfection of systems of multiple-unit control where a number of motors distributed throughout a train can be readily controlled from either end of any one of the motor cars in the train. By the development of this system of control, electric train operation has been simplified; locomotives and accompanying dead weight have been rendered unnecessary for suburban trains; the number of train and switching movements to accomplish a given result have been lessened; and trains of one or more cars can be made up or cut apart, incidentally affording the greatest possible flexibility in dis- the control of main switches, indirect system of control from a small master controller with small currents and train line conductors, automatic progression of switch operation in starting a train, and protective qualities.

The advantage of air pressure as an actuating force for making and breaking switch contacts is that it permits an application of considerable power at the contact with relatively light and simple means, consisting simply of a piston working in an air cylinder, making contact by air pressure and breaking it by a powerful release spring when the air is exhausted. Contact is thus made certain, and welding is prevented at the contact points with the very heavy operating currents that have to be carried. On account of the great power obtained with a small amount of air, the switches can be

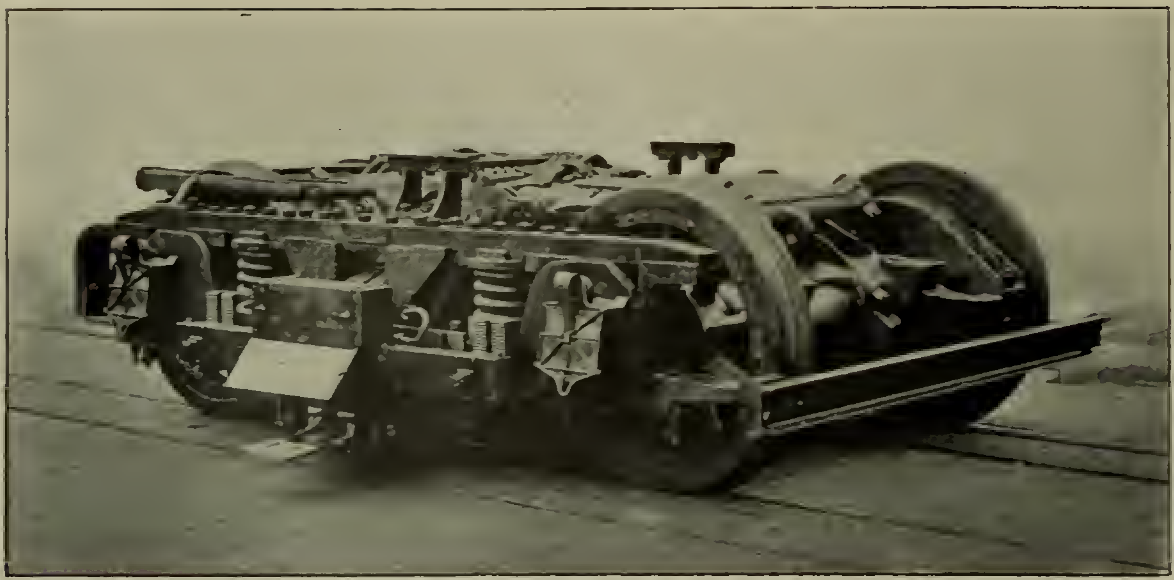


FIG. 11.—A MOTOR TRUCK. THE MOTORS WERE BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, OF PITTSBURG

constructed with large contacts and substantial parts.

The use of storage battery current for controlling the main switches removes the necessity for using line current at 600 volts in the control system, and, further, relieves it from any bad effects that can result from a fluctuation of the potential on the system. As the loads to be carried on the Long Island Railroad are quite heavy, with possibility of extreme fluctuations in potential on the line in regular service, this point becomes important. The likelihood of damage to wiring is less, as 14 volts are far easier to insulate than 600. The certainty of action of the control is with this system entirely independent of the line pressure.

The indirect system of control involves the use of main switches on each car, which are actuated by the movement of a master controller by the motorman. This dispenses with the concentration of a large number of cables and contacts where arcs are likely to be frequent and heavy (as would be the case where contacts are made on a controller of the drum type), and distributes the points of contact in a manner that prevents such risks.

An automatic feature of operation is of importance in securing a regular progressive action of the switches independently of the manner in which the motorman may handle the controller, or of any accident that may happen to the train line. The switches are only moved in a certain predetermined manner, through a system of interlocks, and the operating current is limited to a certain predetermined amount, ensuring a rate of acceleration that is automatically kept constant, which results in maximum comfort to the passengers and a minimum of wear and tear.

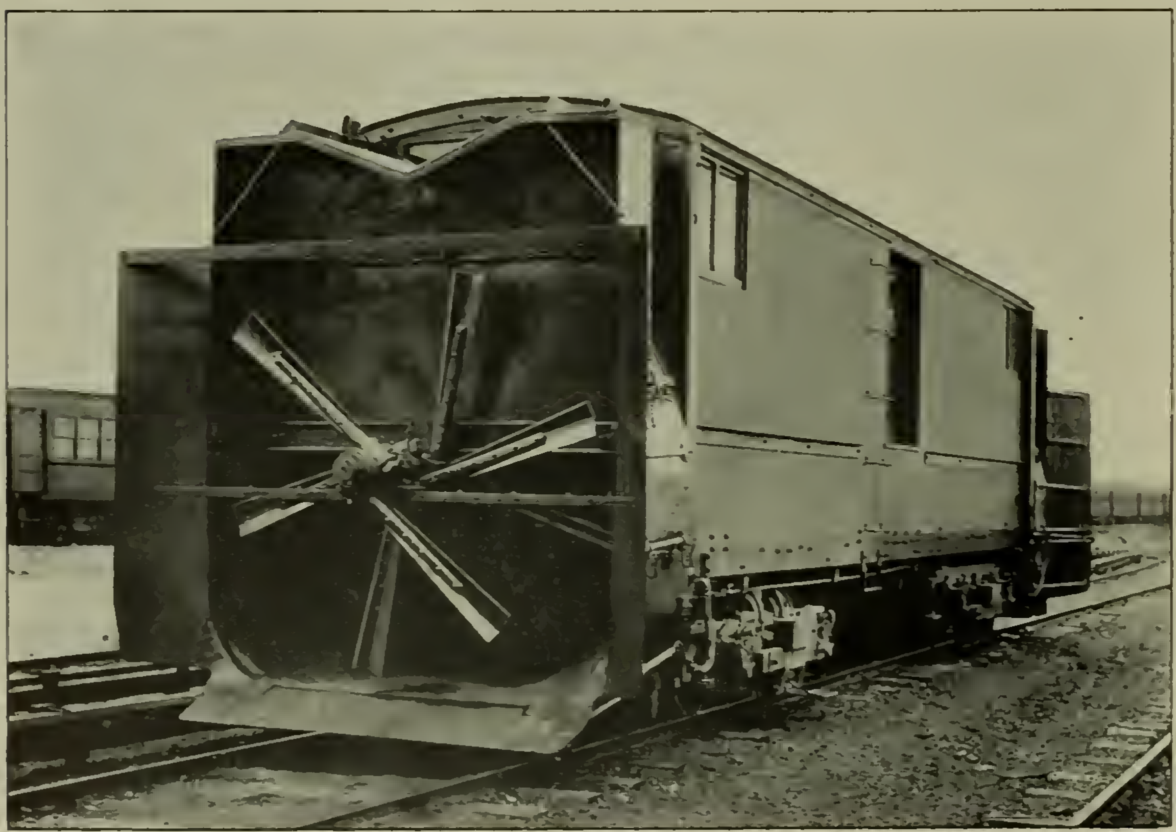


FIG. 12.—ELECTRIC SNOW PLOW BUILT BY THE PECKHAM MANUFACTURING COMPANY, OF KINGSTON, N. Y.

The control system is naturally divided into two general sections:—The main motor control system, through whose connections the current from the third rail is fed into the motors and back again into the track return, and the auxiliary control system, through which, by means of anyone of the master controllers which are placed at each end of every motor car, the motorman actuates the switches which make and break connections in the main motor control system.

Compressed air is used for opening and closing the main motor control switches, the action of the air being, in turn, controlled by electromagnetic valves which are opened and closed by making and breaking the current in their exciting coils by means of the master controller. These valves are light and easily moved, and the auxiliary control system, therefore, operates with very light currents in a train line of seven small wires taking current from an independent storage battery of seven cells carried on each motor car.

The apparatus constituting the main control system comprises the following apparatus:—Group of unit switches, resistances, electrically operated line switch, supply system, comprising the third-rail shoes, supply mains and bus line, connecting the main control apparatus on all the cars, including the necessary fuses and jumpers.

The various details of the design have been carefully worked out to make the control as nearly as possible proof against the errors of the operator or against excess or failure of the main current supply. The connection of the control system with the air brake system lends itself readily to the introduction of features designed to automatically protect the train from accident.

There are four positions of the main control handle, on either side of the central position. When at the central position, the current is off and the emergency brake is automatically applied. At the first notch in either direction from the centre the current is still off, but the brake is not applied. This is commonly called the "coasting" position. The second notch from the centre is commonly called the switching position, because all of the extra resistance is then in series with the motors and control resistance, enabling the car or train to be moved very gently while switching and coupling. The third notch brings the motors to the series position, ultimately working them up to half-speed, while the fourth and last notch is the full speed or parallel position.

The acceleration resulting from the scheme of switch manipulation is very smooth, and the change from series to parallel is not perceptible.

SUPPLY SYSTEM

The supply system begins with the four third-rail shoes mounted upon the trucks, each shoe being provided with an enclosed fuse. The two shoes on opposite sides of the same truck are connected together by a cable run in conduit. From a point just above the inner terminal of one of the shoe fuses the supply main is connected, running direct to a switchboard panel (mounted in an enclosed space in one of the vestibules) with two taps, one of which leads through a bus fuse to a pair of bus line receptacles at each end of the car. The bus line may be considered as a jumper run from one motor car to the next, tapping at each end through a fuse into the supply main wiring of the motor car, thus equalizing the main motor supply circuits throughout the train.

Upon the switchboard is mounted the main switch, which is of a three-bladed, quick-break knife type with front connections. From this main switch the supply line runs directly to the main fuse underneath the car, thence to the electrically operated line switch, thence to the switch group which is connected to the resistances, to the reverse switch and to the motors. One ground connection in the main motor circuit is made from the field of one of the motors to the truck. There is another ground connection made directly from the switch group.

The auxiliary control, which might be termed the nervous system which actuates the muscles of the main motor control comprises an electric circuit receiving its power from a small storage battery of seven cells, two batteries being carried on the car and used alternately, one being charged while the other is feeding the control circuit. This auxiliary control circuit operates, by means of small electro-magnets, the air valves which admit air to the cylinders, the pistons of which, when forced in and out, make and break the contacts of the main control system.

The auxiliary control system is in no way electrically connected with the main motor control system or any of the 600-volt wiring, and is absolutely independent of the main supply system. The apparatus in detail is as follows:—Master controller, line switch cut-out switch, brake cut-out switch, overload trip and reset device, train line, magnet valves and interlocks, line relay, limit switch, control cut-out switch, battery charging outfit.

The trailer cars are fitted with bus lines and third-rail shoe connections for the main circuit, and also with the train line, including the necessary junction boxes and conductor sockets with the auxiliary control circuit, these being necessary for connecting motor cars which are separated by a trailer.

One master controller is placed at each end of every motor car, and consists of a movable drum carrying contact segments, the contacts being made with stationary fingers. The circuits made and broken by these contact fingers receive their current from the 14-volt storage battery. On the face of the master controller there are nine notches or stops, one in the centre and four on either side, which engage the spring catch of the handle. If the handle come to and remain in the centre position, when the brake cut-out switch is closed, the train brake relay valve operates to exhaust air from the brake pipe and causes an emergency application of the train brakes. The first notch is really the "off" or coasting position of the controller, and when the handle is at this point the train brakes are not applied, but all switches, including the line switch, are open. Reversal is accomplished by moving the handle to the opposite side of the centre notch.

When on the second notch or switching position, the controller establishes such connections with the train line that the reverse switch is thrown to the correct position, the line switch is closed, and the switch group closes the circuit of the motors with all the resistance in, thus effecting a slow movement of the train. This, of course, can only happen with all the train line jumpers connected up, so that the auxiliary control apparatus on each motor car is in parallel across the wires of the train line. A single series of contacts made by one master controller anywhere in the train line charges in proper succession all the seven wires constituting the train line throughout the train, and causes identical combinations in the auxiliary control circuit devices to be made in all the cars simultaneously.

The third notch is the series running position, and the fourth and last notch is called the multiple running position, bringing the motors gradually to full speed.

Alongside of each master controller are three auxiliary switches mounted within easy reach of the motorman. As they are intimately associated with the operation of the auxiliary control, they will be described here. The first is the line switch cut-out, which, when the train is in operation, is kept closed, but when open it cuts off the battery current from the electro-magnetic valve that closes the line switch. Consequently the line switch remains open, and it is impossible for the third-rail current to reach any of the apparatus in the main control system.

The second is the brake cut-out switch, which, when closed in its normal position, permits the handle of the master controller when it reaches the central notch to complete a circuit which energizes the emergency train brake magnet valve, immediately releasing the air from the train pipe and setting the brakes. This arrangement makes effective the "dead man's handle" feature of this type of control. If the motorman removes his hand from the master controller handle from any cause whatever, it returns immediately to the central position and sets the brakes.

The third switch is the overload trip reset. Two overload trips are mounted on the unit switch group, and are tripped by excessive current in the main motor circuit. Each trip includes an electro-magnet, which, in lifting its armature when excessive current rushes through it,—that is, through either motor,—breaks the auxiliary control circuit in such a manner that all the unit switch valves are immediately released and the unit switches all open at once, cutting the current off from both motors.

When this trip opens, it stays open until reset. The resetting device consists of a latch which holds the plunger away from the contacts it has just broken, until the latch itself is withdrawn by the electro-magnetic suction of the resetting coil which encircles it and is connected to the overload trip resetting switch in the car vestibule. It should be kept in mind that these three switches, together with the master controller, are so connected to the seven-wire train line that the same results occur on all cars simultaneously when any one of these three switch contacts is closed or opened.

The train line, which comprises seven wires, each having differently coloured coverings, is carried through the entire train by means of connector sockets and jumpers, and is also fitted with three junction boxes on each car, there being one at each end for the connections running to the master controller and the three auxiliary switches, also effecting a junction between the two train line connector sockets which are permanently fixed on opposite sides of the end sill cf the vestibule. The third junction box is used to connect the train line with the battery and with the wires leading to the switch group, line switch, reverse switch and control cut-out.

The current for operating the control system in each car is derived from one of two small storage batteries consisting of seven cells each. These batteries are so connected that one is being charged while the other is working upon the control circuit. The batteries are charged from the circuit of the air compressor motor, which is accomplished by connecting the battery in multiple with an adjustable resistance so arranged that the proper charging current will pass through the batteries when the compressor is operated, the circuit through the battery being closed by a relay mounted on the switchboard panel.

LIGHTING

The lighting of the car is divided into five independent circuits, for interior illumination, besides a separate circuit at each end controlling the vestibule dome lights and the signal markers. The incandescent headlight is in series with a resistance and independent of all other circuits. The headlight is controlled by a separate switch, but the marker and dome lights are so controlled that when the latter are turned out on either end of the car the former are turned on. This is for the accommodation of the motorman, whose vestibule at night must be dark, except for the gauge lamp, while the headlight and markers are to be lit only at his end of the car.

The interior of each car is lighted by twenty-six 16 candle-power incandescent lamps. Two 16 candle-power lamps are placed in each vestibule in such a manner as to effectively light the platform and the steps. One 16 candle-power lamp is located in each marker, and a 50 candle-power lamp is placed in the headlights, which are permanently fixed on the vestibule roof between the markers. Snap switches are placed within easy reach of the motorman for the control of the headlight, the markers and the platform lights. All other light and heater switches and fuses are located on the switchboard.

HEATERS

Electric heaters of the panel type are provided, each having a ventilated sheet-iron back and being placed under the seats. There are twenty-four heaters in the body of the car, and at each end there is one of a special type in the motorman's cab. The heaters inside of the body of the car are proportioned so that each can radiate the heat generated by 600 watts without sufficient rise of temperature to endanger passengers' clothing. The variation in the amount of heat is accomplished by having two sets of heater coils, one of twice the capacity of the other. Either or both sets may be cut in by switches, thus providing three degrees of heat, the distribution being uniform in all parts of the car on any step.

The heating element consists of double galvanized iron wire, wound helically around a porcelain spindle, grooved to receive it. Two of these heating elements, one of twice the resistance of the other, are set in a cast-iron frame with a ventilated back lined with asbestos, due provision being made for the ingress and egress of the air so that it can circulate through the heater.

The heaters in the steel motor cars were supplied by the Consolidated Car Heating Company, of New York. Those in the wooden trailer cars were manufactured by the Gold Car Heating & Lighting Company, of New York, and are cf the truss plank type of construction. The internal arrangement of the Gold heater is of their usual construction, consisting of a special resistance wire wound as a helix and supported on a crimped and enamelled steel rod. There are two elements, as in the case cf the motor car heaters.

The heating circuits are controlled by quick-break knife switches mounted at the top of the switchboard panel at the end of the car. Fuses for the heater circuits are mounted directly below the switches.

WIRING

All wires and cables, for whatever purpose, are run in iron conduits. The leads to motors and third-rail shoes from the car body were covered with a coil of spring brass wire for armour, and carefully cleated to the motors and truck bolster to avoid chafing and to reduce their motion to a minimum.

As already mentioned, in the vestibule at the motor end of the car is mounted the switchboard. A compartment is provided in the end bulkhead with a metal door lined with asbestos material, which, when opened, exposes the entire front of the switchboard panel. The panel is supported by a steel frame, being held in it against a rubber cushion, and are shields of asbestos are provided at all points where arcing from the switches is liable to reach the framework of the car. Additional insulation is provided in the form of "electrobestos" at the sides and top of the switchboard compartment. The power cables are brought into the bottom of the switchboard through loricated conduit, the ends of which are capped with special bell-mouthed castings fitted with rubber rings to prevent damaging the insulation on the cables.

The conduits are of the loricated type, and are run through the framing cf the car according to a well-worked-out plan which is uniform for all cars, the framing being drilled at the proper points before the cars left the builder's shops. To aid in this work, a steel subway car was temporarily secured through the courtesy of the Interborough Rapid Transit Company, and upon it the various details of assembling the electro-pneumatic control and the air brake equipment were so perfected that a standard system of parts, attachments and drilling was determined upon which simplified and hastened the work of installing the equipments upon all the cars.

A temporary plant was placed in operation at the Locust Avenue shops of the Long Island Railroad, fitted with all the necessary tools for manipulating the iron conduit, and the work, after being started at this shop, proceeded with great rapidity until the entire number of 130 steel cars was completely equipped. The motors and all the rest of the equipment pertaining to the cars, except the air brakes, were mounted upon them at those shops.

All the switches except the headlight, marker and platform light switches, which are installed in the platform hoods, are mounted upon this switchboard, as well as certain other parts of the auxiliary control system which have been mentioned in various parts of the preceding description.

AUXILIARY EQUIPMENT

The steel cars as thus constructed and equipped have now been in successful operation for over a year.

Besides the steel cars above described, fifty-five wooden trailer cars, which had been built six or seven years previously with a view to using them in electrical trains, were equipped to run in trains with the motor cars; provision had been made in designing these car bodies for conveniently disposing the electric lighting circuits, but the class of work then in use was not considered safe now. These trailers are 46 feet long and 8½ feet wide, over all.

These wooden trailers had formerly been used in certain Long Island Railroad trains that had been run on the Brooklyn Elevated lines between Flatbush Avenue station and the Brooklyn Bridge. They have open platforms, side doors, and cross-seats, and seat fifty-six people. They were wired for electric lighting and heater circuits, and fitted with bus line and train line connections. The lighting and heater circuits are supplied by a connection tapped from the bus line through a fuse, and leading to a small switchboard panel from which the distribution is made. There are thirty 16 candle-power lamps in each trailer.

Five electric express cars were provided, equipped with the standard type of motor and trailer trucks, two 200-H. P. standard motors, and with the standard multiple-unit control apparatus. These cars haul the old standard steam baggage and express cars as trailers.

Reference has been made in the former article describing the sub-stations to the two all-steel portable sub-station cars which were designed to carry a complete rotary converter substation of 1000 KW. capacity, being so fitted that they can be used at a number of different places on the system on the Long Island Railroad where connections to the high and low-tension systems of distribution could readily be effected. The car is carried on a freight truck of the standard type, and is not equipped with motors, but is hauled from one place to another.

Its superstructure is so constructed as to be readily taken apart in order to enable the machine to be run into a sub-station and placed underneath the travelling crane in case it is necessary to repair the apparatus. These cars were primarily intended to be used at the race tracks during the racing season when the loads are particularly heavy but have also been found quite useful at other points since operation began.

A rotary snow plow has also been provided, built by the Peckham Manufacturing Company, of Kingston, N. Y., and equipped with one motor and one trailer truck of standard type, and all of the standard motor car electrical equipment. A set of revolving blades with fan and housing is mounted at each end of the car, operated by one line shaft running through the car and fitted with two friction clutches, one for each end section, the centre section carrying two 50-H. P. railway type motors, run by a series parallel controller of the standard platform type. A view of the plow is given in Fig. 12.

In order that all the electric car equipment might be given a thorough service test, and the apparatus properly adjusted before going into the regular passenger service, the section of the line known as the Old South Road, between Jamaica and Springfield Junction, was equipped with third rail, and all the car electrical equipments were subjected to service running tests in trains of various lengths, and given a continual inspection to insure that all apparatus was in proper order.

These tests also served the purpose of instructing the motormen and familiarizing them with the car and operation of the car equipments and brakes.

CAR SHOPS

The facilities for inspection and repair of electric cars of the Long Island Railroad system consist partly of a section of the original car shop at Morris Park, near Jamaica, which has been, to a certain extent, remodeled to better accommodate the new motive power, and two inspection sheds, one located at Rockaway Park, at the extremity of the Rockaway Beach Division, the other being at Dunton, which is between Morris Park and Jamaica, on the Atlantic Division. The two latter structures are entirely new, and are fitted only for the inspection of trains, while the car shops at Morris Park are fitted with the necessary machine tools for executing repair work.

Besides the repair shop facilities at Morris Park, two inspection sheds have also been provided for effecting the periodical inspection and light repairs that are required to keep the cars in fit operative condition. The smaller of the inspection sheds is adjacent to the Rockaway Park terminal. The larger inspection shed is located at Dunton, on the Jamaica Division, directly west of Jamaica. This building is about double the size of the former, being designed to afford inspection facilities for all the cars on the Atlantic Division, which is a busy line all the year around. The building is constructed entirely of reinforced concrete, with roof trusses of steel plate girders supported in the centre of the building on lattice columns.

The Rockaway Park inspection shed will accommodate twelve cars, and that at Dunton twenty-four. The latter station is provided with room for an office upon a gallery running across one end of the building, reached by an iron staircase coming up between the tracks.

The Dunton inspection shed is equipped with lavatory conveniences. At Rockaway Park the lavatory is situated in the terminal station adjacent. Both sheds are fitted with electric lighting, the wires being run in iron conduit, and receiving current from the third rail.

ORGANIZATION

The equipment of the steel passenger cars, the auxiliary rolling stock, and the building of inspection sheds were carried out by Westinghouse, Church, Kerr & Co., who, as in the other portions of the complete equipment, acted as constructing engineers. The entire work of design and construction was in charge of George Gibbs, chief engineer of electric traction of the Long Island Railroad.

CONCLUSION

With the preceding account of the electrical car equipment, the description of the newly installed system for operating the Long Island Railroad trains with electric power is brought to a close. The car equipment has proved itself in every way equal to the demands made upon it both for regular and emergency conditions of travel.

The electro-pneumatic, multiple-unit control system has worked perfectly from the start, and throughout the entire installation, including the power station, transmission system, sub-stations and cars, the endeavour was made not only to take advantage of the most recent progress, but, as opportunity offered, to establish new precedents in the art. In achieving the distinction of being the first one of the main steam railroad lines to initiate and make effective the change of motive power for its suburban service to meet the needs of its territory, the Long Island Railroad Company has set an example of foresight, thoroughness and sufficiency in the execution of the undertaking.

The contract with the American Car & Foundry Company, of Berwick, Pa., for the steel car bodies was let on January 20, 1905. The first car body was received at the Locust Avenue shops for equipment early in April, 1905, and another one was exhibited at the International Railway Congress in Washington early in May. By August, 1905, the entire number of steel cars had been delivered at the shops, where they were mounted upon trucks and all parts of the electrical equipment assembled. During the summer the cars were equipped at the rate of ten per week.

The first test of a completely equipped car was made on May 13, 1905. A month later, fully equipped trains were running on the branch between Jamaica and Springfield for testing the equipment and for the instruction of the motormen. Regular electrical operation was first inaugurated between Flatbush Avenue and Rockaway Park on July 26, 1905. Service between Flatbush Avenue and Rockaway Junction was inaugurated on August 30. In October the heavy excursion traffic to and from the Belmont Park Race Track was successfully handled. On December 11 the electric service was extended to Far Rockaway and Valley Stream, and the use of steam locomotives for hauling passenger trains to and from the Brooklyn terminal of the Long Island Railroad was discontinued.

On April 27, 1896, the act creating the Atlantic Avenue Commission passed the New York State Legislature, this being the formal beginning of the working out of a transportation problem that was of immediate and far-reaching importance to the citizens of Brooklyn and the Long Island Railroad. Several years elapsed before the results of the work, first of the Commission and then of the Board of the Atlantic Avenue Improvement, began to be noticeable, but it progressed year by year until finally consummated on the above date, a little less than ten years from its inception.

The respective parts taken, first, by the Atlantic Avenue Commission in formulating a concrete plan of improvement of such far-reaching importance, and later by the Board of the Atlantic Avenue Improvement in planning and executing the work, and by the Long Island Railroad in co-operating with all the duly constituted authorities for the advancement of a plan so conducive to the welfare of the community served by it, have not been enlarged upon in the foregoing technical description of the work, but they are now matters of history, a full knowledge of which is available for other municipalities and corporations which may be confronted by similar problems.

But the record will be incomplete without an acknowledgment of the credit due to the late William H. Baldwin, Jr., president of the Long Island Railroad from 1896 to 1905, whose foresight, public spirit and initiative played such a leading part in the solution of a difficult rapid-transit problem. Could he have lived but one year longer he would have witnessed the consumption of his labours, which have conferred a lasting benefit on the community.

Gas Engines in German Smelting Works

At the recent joint meeting of the Iron and Steel Institute and the American Institute of Mining Engineers, in London, K. Reinhardt gave some statistics regarding the use of Gas Engines in German Smelting Works.

In actual operation on March 1, there were 203 engines having a total effective horse-power aggregating 184,000. In course of erection, or on order, there were 146 engines aggregating 201,000 H. P. Of a combined total of 385,000 H. P., 64 engines were of the single-acting four-cycle pattern, accounting for 34,000 H. P.; 88 were of the single-acting two-cycle pattern, amounting to 81,000 H. P., and 197 were double-acting four-cycle motors amounting to 260,000 H. P.

In order that the tally may be as nearly up to date as possible, the author notes that there has been ordered between March 1 and July 1, of the current year 31 engines aggregating 36,150 H. P.; 14 of these are to be used for driving blowing engines, seven being two-cycle engines, and seven double-acting four-cycle motors, the respective aggregate powers being 7800 and 9400. For driving dynamos, 17 double-acting four-cycle engines were on order, these aggregating 18,950 H. P.

Taking present installations and present orders, there will be at work 161,300 H. P. for blowing purposes, 16,100 H. P. for driving rolling-mills, and 206,100 H. P. for driving dynamos. Of the 199 engines falling under the latter category, 48 are single-acting four-cycle motors, 41 are two-cycle motors, and 110 double-acting four-cycle motors. The largest aggregate installation at any single works is of 35,000 effective horse-power; 16 works possess over 10,000 H. P., and 27 works over 5000 H. P., all in actual working.

In most of the ironworks the gas engines work continuously without any reserve engine power; a few have up to 40 per cent. reserve of gas engines, and a few have a similar reserve of older types of steam engines and steam turbines. Nearly all the engines in ironworks use blast-furnace gas. Two plants use only coke-oven gases, three use blast-furnace gas and coke-oven gas separately, and one plant uses the two gases mixed. The Mansfeld Company utilizes the waste gases from the copper smelting furnaces for driving gas engines. Producers employing coke as fuel are kept as a reserve at seven works; these are for use only in case of a strike, to assure the working of the most necessary part of the plant.

The conditions existing in all round houses, says "The Railway Master Mechanic," are such that the standard method of wiring for lighting, namely, that in which the wires are encased in steel pipe or conduit drifted, reamed and especially prepared as approved by the National Board of Fire Underwriters, and the open method of supporting the wires by means of porcelain cleats or knobs, do not fulfill requirements. This is because of the destructive effect of gases and steam to which wires are subjected in round houses. A method recently adopted by one of our leading railroads, to overcome this effect of gases and protect the wires as much as possible, is to place all wiring within fourteen feet of the floor, or below the gas belt, and locate all main wires outside with a fuse protecting each stall. Some railroads have installed a conduit system on the roof of round houses. However, there is always a certain amount of gas at this location, especially in heavy weather, which in time is liable to effect the pipe where joined to the boxes. This would probably cause a ground in time which would be hard to locate. Also it would be difficult to repair the wires and place them in as good condition as when originally installed.

Some particulars of Osmin lamps, the trade name for the Austrian osmium filament lamps, were given in a paper by A. Libesny, read recently before the Elektrotechmischer Verein, of Vienna. The great disadvantage of these lamps has been their low resistivity, until recently the highest voltage possible with a practicable length of filament being 37. Now, however, lamps of 36 candle-power for 120 volts and of 72 candle-power for 200 volts are available. Tests on these lamps gave an initial consumption of 121 watts per candle, and during 1776 hours of burning, the average consumption was 1.22 watts per candle. At the end of that period, the lamps still maintained 80 per cent. of the original candle-power.

There are now 158,874 Bell telephones in use in Chicago. For the month of July the increase was 1552.

Contracting for Use of Hydro-Electric Power on Railway Systems

By G. A. HARVEY, Electrical Engineer, International Railway Company, Buffalo

A Paper Read at the Recent Convention of the New York State Street Railway Association

THE majority of railway managers and engineers in this section of the country have had occasion during the past few years to consider the subject of using electric power developed from water-power for the operation of their cars.

The first point for definite investigation is invariably the matter of cost, as it has long ago been shown that electricity can fulfill all the power requirements of any sort of transportation system. If the system of the prospective purchaser happens to be so fortunately located that he can receive offers from different sources, his inquiries are apt to bring together figures which, at first sight, appear to be widely at variance and cause him to conclude that there are excellent opportunities for bargaining. Investigation soon shows, however, that the prices are not very unequal if the use of power under the different proposals is reduced to a uniform footing, and the fact at once becomes apparent that the most advantageous conditions are those under which the consumer uses power at a high load-factor.

The effect of load-factor on cost of power is thoroughly understood where steam plants are concerned, but it might be supposed in the case of hydraulic power, where no furnaces have to be banked and inefficiency at light loads becomes unimportant, that the conditions would be different. Hydraulic turbines of modern design, however, usually have such characteristics that their overload capacity is very slight, and it, therefore, becomes necessary, if peak-loads are to be handled, to provide extra machinery to take care of these.

With no provision for peaks it is still necessary to hold at least one generating unit in reserve, and a margin of capacity must be left unused in the operating turbines for gate travel in regulation, and to allow for partial clogging of distributors by refuse which accidentally enters the penstocks. As the water is available and costs no more if used to the full capacity of the plant, it is plain that the power-selling company will strive vigourously for a uniform load as high as is practicable for the installed machinery to carry. This results in making peaks a prohibitive element to power deals where greatest part of the power now developed.

The foregoing is not intended to convey the idea that railways cannot contract advantageously for hydro-electric power. The typical street-railway load necessarily has prom-

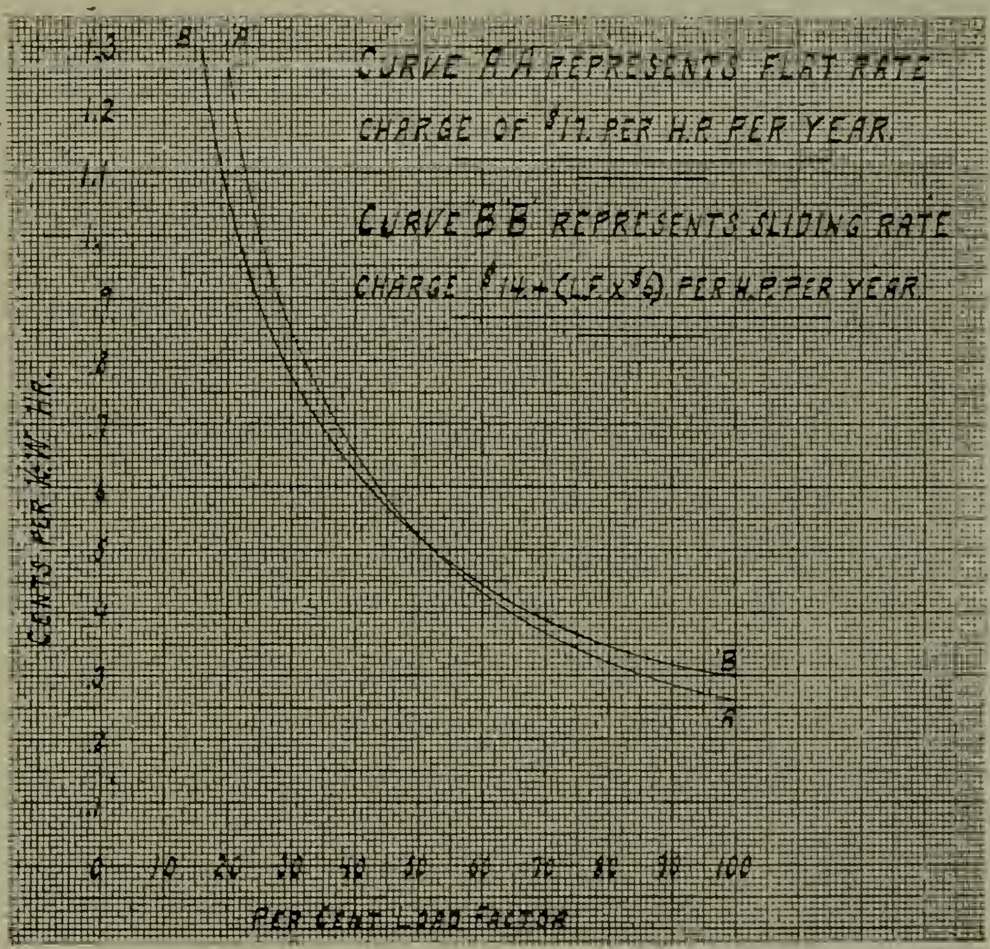


FIG. 1.—SHOWING SUGGESTED PLAN FOR CHARGING FOR ELECTRIC POWER

the hydraulic plant has been some time in the field and has been able to discriminate in the choice of its customers.

The plants now operating at Niagara Falls have been particularly fortunate in this respect, one of the oldest having a twenty-four-hour load line of about 26,000 H. P., and fluctuations not exceeding 5 per cent. of the average load. Needless to say, the portion of this power supplied for railway and lighting purposes is very small. The Niagara conditions are unique on account of the electrochemical plants which provide an ideal load and consume the inent peaks, and, if these cannot be smoothed down by adjustments of service, it is still possible, where a fair price is asked for the water power, to carry the heaviest part of the all-day load by means of this and the remainder by steam engines, gas engines or storage batteries, or combinations of engines and batteries.

The point is frequently raised that power companies undertaking to supply customers of any sort should be equipped to take care of all requirements of these customers, including peak-loads. This is done in some cases, the power companies going so far as to provide steam plants

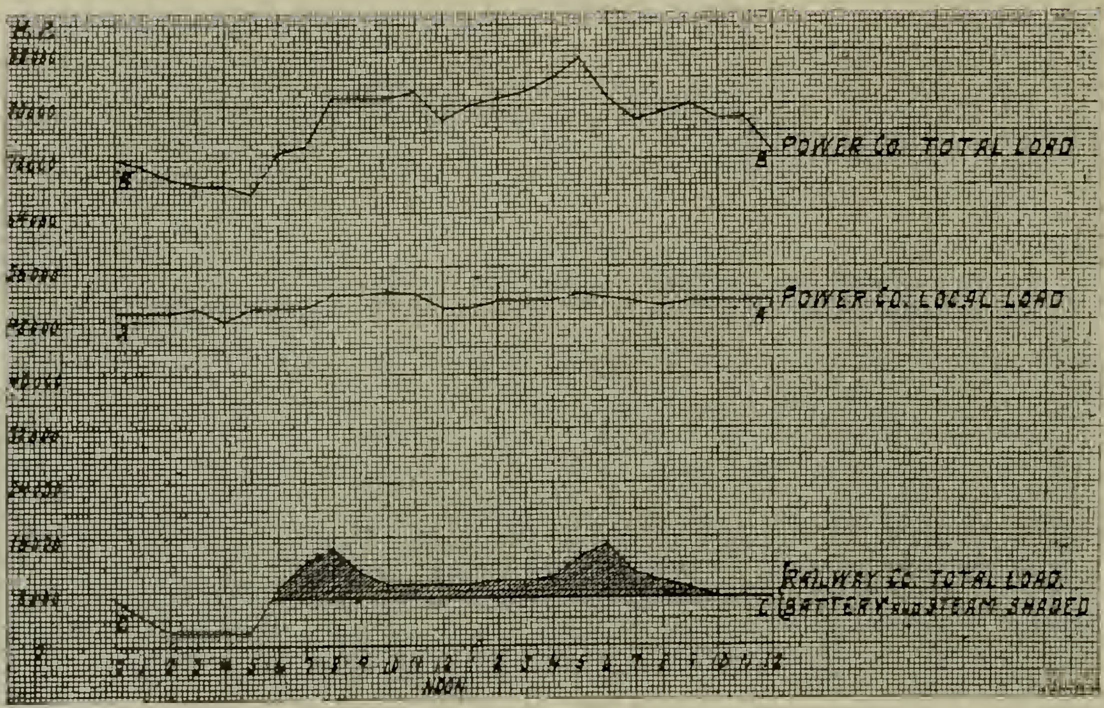


FIG. 2.—SHOWING LOAD CURVE OF ONE OF THE NIAGARA COMPANIES

for reserves and peak purposes. The character of local demands for power will usually determine this matter, and if the power companies eventually install auxiliary steam plants, it will be only because they are forced to it by periodic shortages of water or inability to obtain customers whose aggregate use of power results in a high yearly load-factor.

The power company wants to sell all of its power all of the time, and in a thriving, progressive community it is probable that it finally will come very near doing this. The load-factor will improve as customers increase in number, and as the load approaches the full capacity of the plant the power company will become more discriminating about

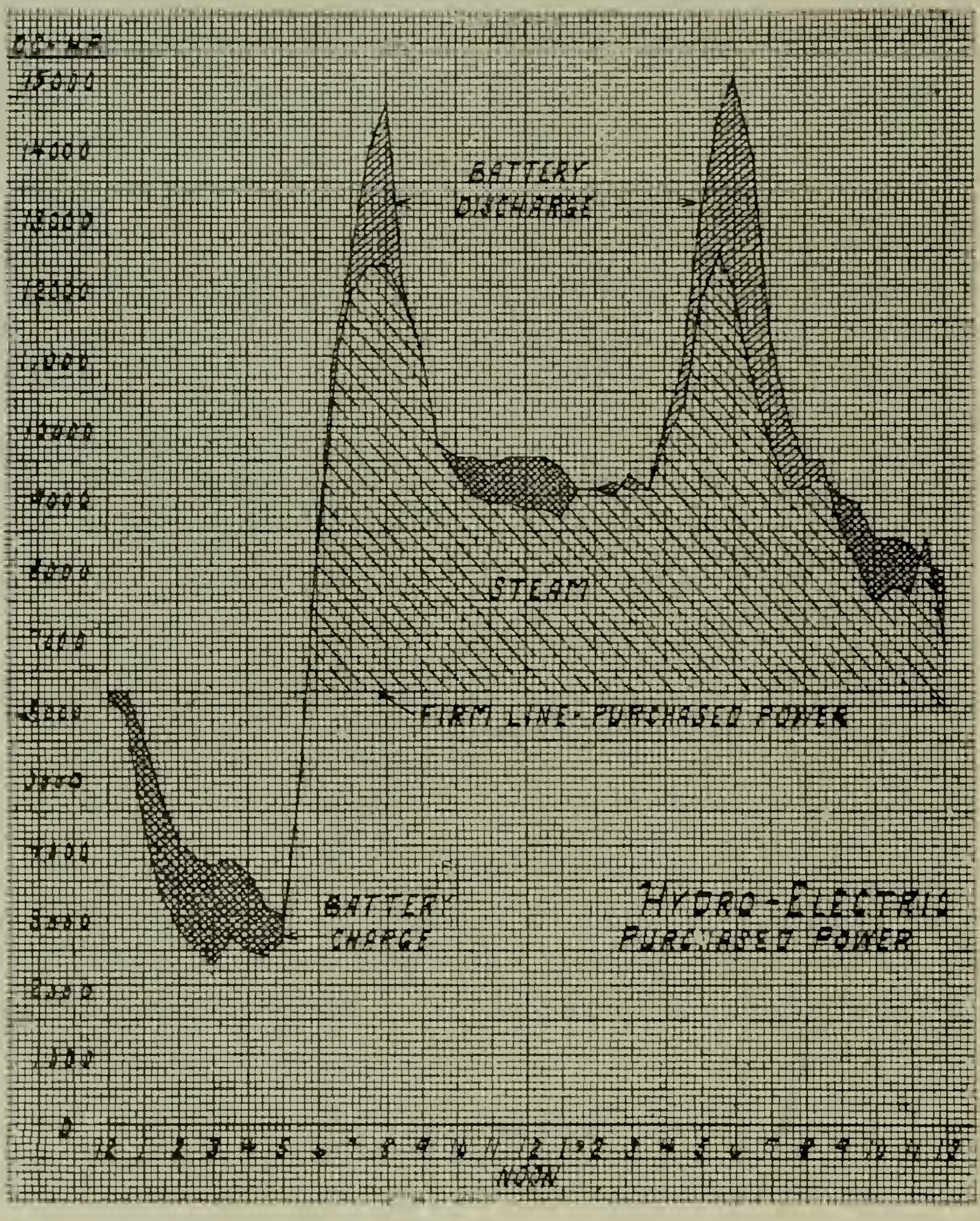


FIG. 3.—SHOWING LOAD LINE REPRESENTED AS C C IN FIG. 2

closing new contracts, or renewing old ones, that involve conditions tending toward poor load-factor. When power plants are new, and struggling for an early return on investment, there are good chances of railway companies being able to contract with them for power to cover full requirements.

In making such agreements it is well for railway companies to make the contract period of considerable duration, as there is little likelihood of rates being dropped by competition, except in such localities as Niagara, and there is also small chance of any other power being able to underbid the price of hydro-electric power where conditions are at all favourable to the latter. Power contracts covering periods of twenty years or more are not unusual. In drawing such agreements there should always be provision for increasing the amount of power, at the same or better rate, as the railway service grows, and it is well to specify that if power is later sold at a lower rate by the power company to other parties no more favourably situated, the railway company is also to have the benefit of such rate.

If it is possible to make contracts for full power requirements, it is usual for power companies to place some penalty rate on the peak power or to arrange the terms of charge so that there are distinct advantages to the purchaser in keeping the load-line as nearly straight as possible. The most common method is to sell a solid block of "firm" power, which can be used at a load-factor of 70 per cent. to 80 per cent. or better, charging the minimum flat rate for this, and providing power above the firm amount on a kilowatt-hour basis at rates gradually increasing with the height of the peaks.

Sometimes provision is made for charging extreme rates for possible peaks of such height that the railway company has no expectation of ever reaching them. These clauses should be avoided, if possible, as the unexpected is constantly happening in the operation and growth of a railroad. Where measurement of peaks is dealt with at all, it should be specified that they are not to be counted unless they continue for two minutes or longer. Uncontrollable occurrences, such as the partial grounding of a feeder, or the performance of a defective car, may produce peaks of short duration which are of small consequence to the power company, but might be very costly to the railway company under an unreasonable power agreement.

A very fair method of billing for

power is on a sliding rate depending on the monthly load-factor. The maximum two-minute peaks are recorded in kilowatts each day and averaged for the month. The total number of kilowatt-hours for the month, divided by the kilowatt of this average peak times the number of hours in the month, represents the monthly load-factor.

The charge for the month is then made up as follows:—A definite service charge + (load-factor × a fixed amount) × average daily maximum kilowatts. A moderate penalty for peaks is thus included, and the customer pays, according to the load-factor, as nearly for what he consumes as can be expected. This method of charging is now being offered extensively by one of the companies which is about to do business over a large portion of New York State. In effect, it corresponds very closely with a flat-rate charge, but gives the purchaser a slightly less cost per kilowatt-hour at low load-factors, as shown by the curves in Fig. 1.

The total load of most any street railway is pretty sure to have a load-factor of less than 50 per cent. If the details of peak-power measurement are successfully carried out in practice, this plan of charging will probably prove popular when customers become familiar with it.

If power companies cannot entertain peak propositions at all, or if they place prohibitive rates thereon, the purchaser must then provide the steam plant or storage battery, or both, to care for a part of the load. In this case the hydro-electric power purchased should form the solid twenty-four-hour base of the area inclosed by the total load-curve, and should extend up to such height as to cover a chart area bounded at the top by a line closely corresponding with the base of the average daily fifteen-hour load-peak.

The purchaser should be allowed, without charge, swings of about 10 per cent. above the firm line of purchased power, provided the kilowatt-hours used above the line do not exceed those unused below it. It is impossible to always carry the load directly on the limiting line, even with the aid of batteries and the most approved regulating devices. The 10 per cent. savings should be allowed for this reason.

Very careful consideration must be given to proportioning the division of load to water power and steam power. The cost of hydro-electric power at 100 per cent. load-factor should be somewhere in the neighbourhood of one-third the cost of steam-generated power at 100 per cent. load-factor, assuming reasonable first cost of plant and moderate distance of transmission in the first case and average cost of coal and labour in the second case.

Obviously, the bulk of the load should be carried by the purchased power, but the higher the limiting firm line of this power is raised the lower will be the load-factors of both steam power and purchased power become, and the cost per kilowatt-hour of each will increase. There is a certain critical point, however, to which the firm purchased power line may be raised before the total cost (which is of prime importance) of combined purchased power and steam power will commence to increase. In raising the firm line of purchased power to this point the total cost will be decreasing.

It is hardly possible to evolve an exact formula for the location of the firm line of purchased power, and if one were worked out the weekly variations of load conditions would probably make its accuracy look doubtful. A safe point for this line is at such height that the fifteen-hour daily use of purchased power will be fairly close to it at all times. It is important, in starting to make this adjustment, to know the cost of steam power per kilowatt-hour at various load-factors under local conditions.

Railway systems supplied with purchased hydro-electric power afford ideal opportunities for application of storage batteries. The batteries can be charged at night with power that otherwise could not be used, and the discharge of the load-peak provides power at an extremely low load-factor which costs only the fixed charges, operation and maintenance of the battery.

The possibility of power interruptions should be recognized in agreements and have penalties placed upon them. An interruption of six minutes is of comparatively small consequence to the railway, and might be ignored if not repeated too fre-

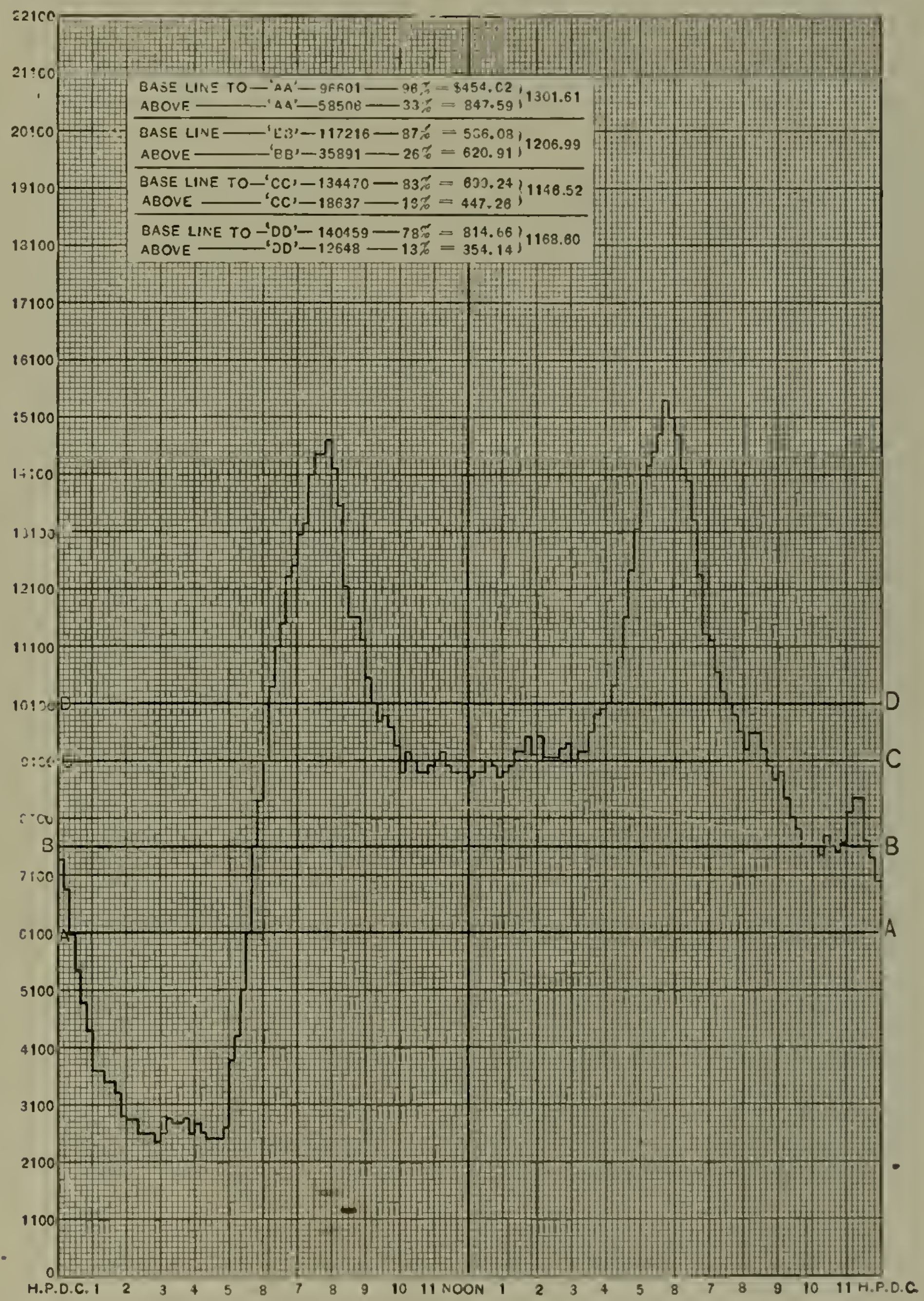


FIG. 4.—A LOAD CURVE WITH FIRM LINES LOCATED AT DIFFERENT POINTS

quently. Interruptions due to lightning, mistakes in switching, cable burn-outs, etc., are bound to occur, and six minutes are a reasonable allowance for testing cables and lines and returning power. Longer interruptions should entail forfeitures by the power company, increasing considerably in amount as the length of interruption increases. A mere abatement of power charge during an interruption is practically no consideration at all. Power companies, by providing sufficient reserve apparatus, lines, cables, etc., will protect themselves against penalties and insure their customers against interruptions.

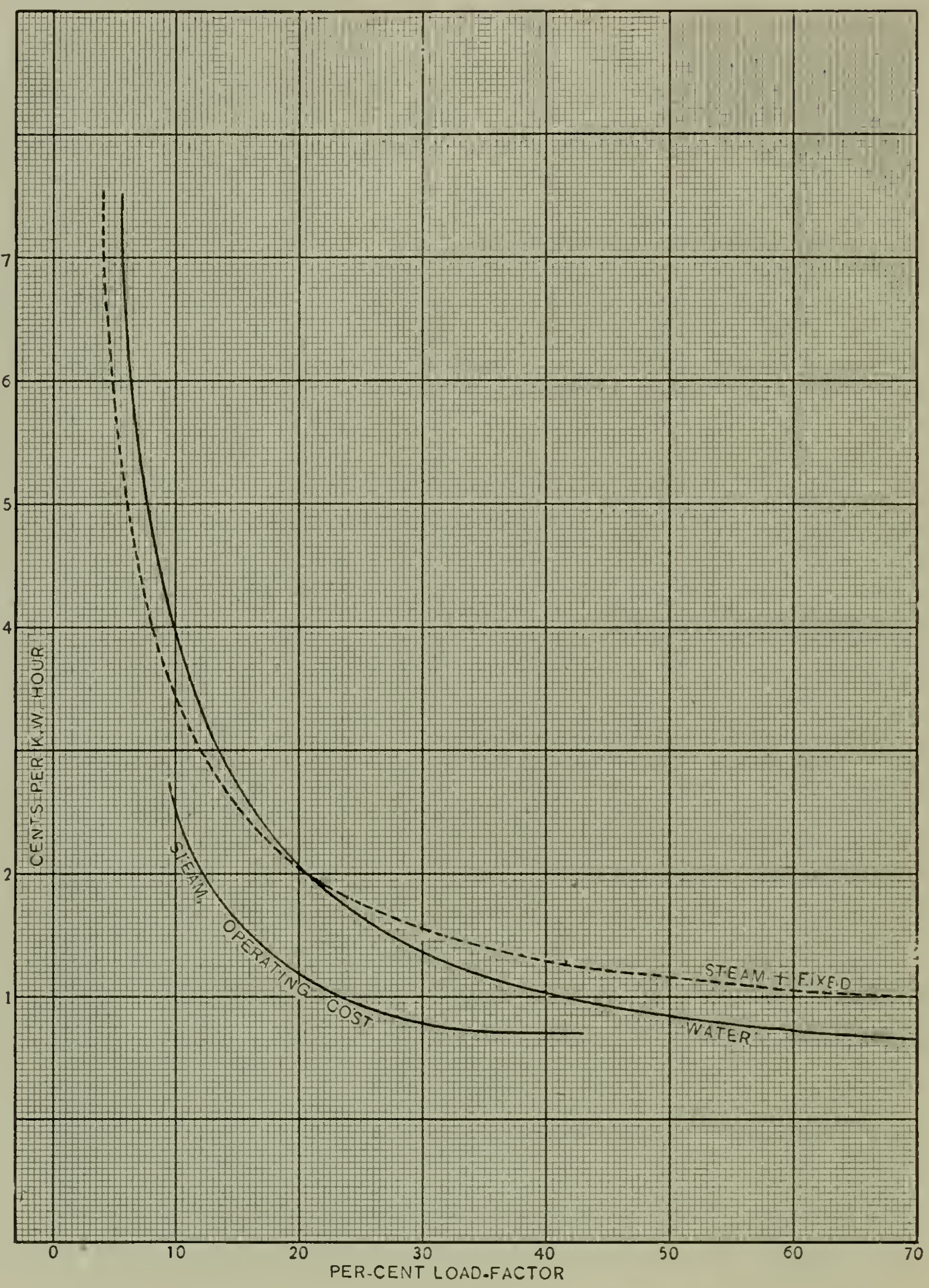


FIG. 5.—CURVES OF COST PER HORSE-POWER PER YEAR, IN TERMS OF LOAD FACTOR AND PRICE PER KILOWATT-HOUR; AND CURVE SHOWING OPERATING COST ONLY OF STEAM PLANT

Purchased power should be delivered on the premises of the purchaser by means of cables and lines installed and operated by the power company. Measurements for determining monthly bills should be made on the purchaser's premises, the power company supplying and maintaining the meters for this purpose. These meters should be checked each month. The railway company should take daily readings from them, keeping a permanent record in chart form which will show hourly changes of total load and any important sub-divisions of load.

Such records are invaluable in adjusting the use of power to the most economical conditions and in figuring on extensions of the system. They are needed for daily reference, and, if the meters on which readings are taken for rendering bills do not provide proper character of measurements for making up load-curves, other suitable instruments should be installed.

Fig. 2 shows at *AA* the remarkably straight local load line of one of the Niagara power companies. At *BB* is shown the total load line, including the long-distance load, of the same company. *CC* shows a railway load, the shaded portion of which is carried by the railway company's steam engines and storage batteries. The unevenness of the power company's total load is not contributed to by the railway company except to the extent of a dip during the early morning hours. The peaks of the railway load would, if included in the power company's total load, distort it considerably in an undesirable way. The curves are all plotted from the same base line and represent the same day.

Fig. 3 shows on a more open vertical scale the same railway load that is represented at *CC* in Fig. 2. The firm line of purchased power is here located lower with reference to the total load than has been described as the economical point. This is partly for the reason that the chart represents a winter day, the heavy load season of the year. The total load drops below the firm purchased power line during the middle of the day at some seasons and, as the firm line cannot be shifted back and forth, there are necessarily times when the proportions of purchased power and steam are not the most economical, as in the instance of this particular day.

In cases where steam plants are already in service on railway systems where the companies commence buying additional power, the interest, depreciation, etc., on these plants, although charged to total cost of power, should not enter into the cost of steam-generated power when balancing up the amount of this to be used in conjunction with the purchased power. The steam plant's fixed charges continue, regardless of the power turned out, and only the actual operating expenses, such as coal, labour, etc., should be figured against the steam power in this case.

If the steam plant is installed, either at or after the time of contracting to buy power, the fixed charges might be considered as against "peak-power," but it does not alter the case materially in proportioning the amount of steam power to be used. Operating cost per kilowatt-hour at various load-factors and the normal capacity and dependable overload capacity are the governing features.

As an example of the economical location of the firm line of purchased hydro-electric power, a load curve is shown in Fig. 4. The experimental firm lines are located on the total load curve at the points *AA*, *BB*, *CC* and *DD*.

With the firm line at *AA* there are 96,601 kilowatt-hours, with 96 per cent. load-factor below the line, costing $454.02, and 56,506 kilowatt-hours with 33 per cent. load-factor above the line, costing $847.59, or a total power cost of $1,301.61.

With the firm line at *BB* there are 117,216 kilowatt-hours below the line, with 87 per cent. load-factor, costing $586.08, and 35,891 kilowatt-hours above the line, with 26 per cent. load-factor, costing $620.91, or a total power cost of $1,206.99.

With the firm load at *CC* there are 134,470 kilowatt-hours with 83 per cent. load-factor below the line, costing $699.24, and 18,637 kilowatt-hours with 16 per cent. load-factor above the line, costing $447.28, making a total power cost of $1,146.52 for this location of firm line.

With the firm line at *DD* there are 140,459 kilowatt-hours below the line, with 78 per cent. load-factor, costing $814.66, and 12,648 kilowatt-hours with 13 per cent. above the line, costing $354.14, or a total of $1,168.80.

These costs are based on the assumed figures of $50 per horse-power-year at 100 per cent. load-factor for steam power, and $30 per horse-power-year at 100 per cent. load-factor for hydro-electric power, as shown on curves in Mr. Storer's paper on "Sale and Measurement of Power."*

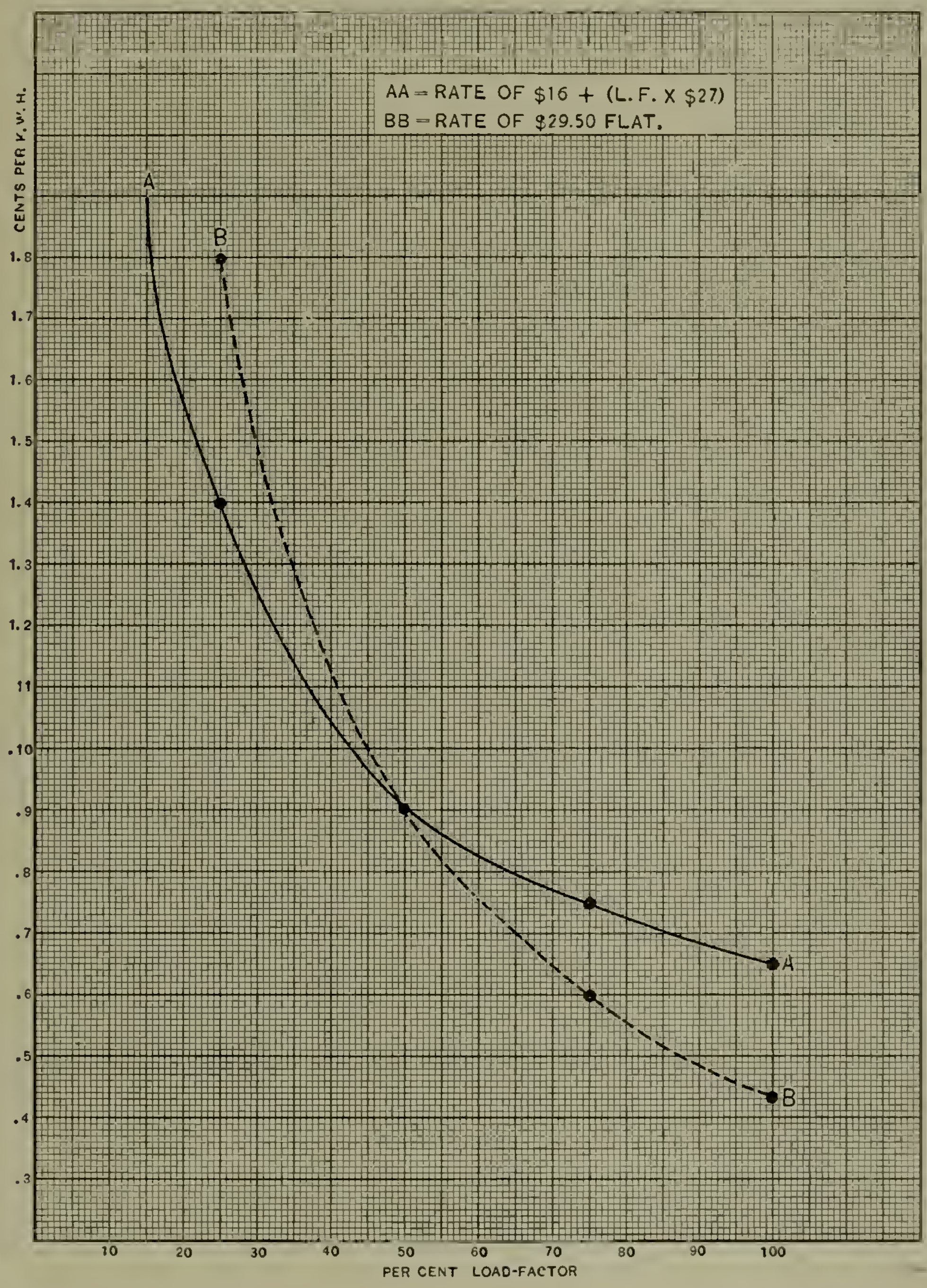


FIG. 6

It is to be seen that in raising the firm line of purchased power from point *AA*, the total cost decreases up to the point *CC*, and then increases at the point *DD*. The economical location for the firm line at these prices for power is, therefore, somewhere in the neighbourhood of the line *CC*, which represents, as previously suggested, the base of the fifteen-hour load-peak.

As previously mentioned, the fixed charges on the steam plant should not be considered in determining the relative amounts of steam power and purchased power to be used, but merely the operating costs should be considered in connection with the steam power in this case. The fixed charges on the steam plant still enter into the total cost of power.

Fig. 5 shows a reproduction of Mr. Storer's curves. There is added, however, another curve showing operating cost only of steam power per kilowatt-hour at various load-factors. Using figures derived from this latter curve, the firm line of purchased power would obviously be located at a lower point than *CC* in Fig. 4, and instead of the steam plant being economical only under conditions where the load-factor is 20 per cent. or less, it is economical over a considerably greater range, as the curve of operating cost of steam plant will cross the water-power curve at a point somewhere near 50 per cent. load-factor.

Taking Mr. Storer's example of a rate per horse-power per year of $16 + (load-factor × $27), and plotting this in terms of cost per kilowatt-hour at various load-factors, we have the curve *AA*, Fig. 6. As power companies seldom hesitate to offer a flat-rate contract, it would seem that the rate depending on load-factor could be appropriately compared with the flat-rate which comes closest to the same effective cost per kilowatt-hour. Such flat-rate would be the one which equals at 50 per cent. load-factor, the 50 per cent. load-factor of the $16 + (load-factor × $27) rate.

This flat-rate curve is shown at *BB*, Fig. 6, and represents a rate of $29.50 per horse-power per year. There is an inconsistency in this, as the rate depending upon load-factor makes the cost to the customer lower at a low load-factor and higher at a high load-factor, which is contrary to the arguments always presented by power companies. This same inconsistency exists in the rates shown on the curves in Fig. 1, but the differences between the lines are not so great.

The compilation of the Technolexicon, which the Society of German Engineers undertook about four years ago, under the direction of Dr. Hubert Jansen, of Berlin, is nearing completion, and printing will begin early in 1907. Publication will be in English, German and French. About 2000 firms and individuals have collaborated in the enterprise and over 3,000,000 word cards have been collected.

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* The reference is to a paper on the "Sale and Measurement of Electric Power," presented by S. B. Storer, general manager of the Niagara, Lockport & Ontario Power Company, at a meeting of the Street Railway Association of the State of New York. This paper was reprinted in the August number of "The Electrical Age."

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Leading Articles

The Electric Flatiron

IN the article on "The Electric Home," and that on "The Organization and Conduct of a new Business Department," elsewhere in these pages, attention is again drawn to the electric flatiron. Perhaps no single device is becoming of such importance to central stations as is this for an entering wedge in the securing of new business. Whether heated by coal, gas, or electricity, a flatiron is a necessity in every home, and if its added convenience can be impressed on the housekeeper by an actual trial, a long stride will be made in convincing the consumer of the advantages of using current for other purposes.

At this time, as the best part of the summer is over, it might seem hardly well advised to tell prospective customers of the opportunity which the electric flatiron offers for escaping the heat of an ironing day. Nevertheless, much of the weather in September is warm enough to make the heat of a gas or coal range unbearable, and furthermore, be it summer or winter, there is always the advantage of saving the countless steps between the fire and the ironing board.

Whether or not a favourable impression may be created by a 30-day trial, depends largely upon meeting the conditions. If the iron is to be used in the sewing room for pressing or for other light work, then one of smaller size should be installed. If laundry work is to be done, then a large-sized iron should be used. Nothing can hurt the prestige of the electric flatiron so much as the unsatisfactory results obtained by using a small iron for heavy work. Here as elsewhere the conditions must be studied. No central station man would think of installing a motor for power without first finding out the nature and the amount of work to be done.

That it may be necessary in some cases to loan the iron to the consumer is apparent from what Mr. Kennedy says about the action of his company in this regard. That even on this basis the investment in irons will yield a profitable return is apparent from a moment's consideration. One estimate has placed the number of electric flatirons in use in the United States at 300,000 or 400,000, and another at 100,000. Let us take 250,000 as a fair average. Assuming the cost of these to be $3.75 each, makes the total investment $937,500. Suppose interest and depreciation increases this to $1,100,000,—certainly a safe margin. If each iron consumes $8 worth of energy a year,—using Mr. Kennedy's figure,—the gross revenue would be $2,000,000. The net revenue would then be $900,000 a year, or nearly 100 per cent. on the investment. This plan, therefore, certainly deserves serious consideration as a means of breaking down the opposition of customers to any initial cost. It is in the nature of a "bargain," which should appeal to many housekeepers.

That many central stations are alive to the opportunities which the electric flatiron affords for increasing business is evidenced by figures gathered recently by Mr. Loewenthal. In Spokane, Wash., 2,0000 irons were placed in homes in the past six months. This figure represents 5 per cent of the entire population. Several other cities have introduced between 500 and 2,000 irons in the same period.

In New York, their introduction is somewhat retarded for several reasons, one being the difficulty of getting in touch with the consumer and another being the attitude of the underwriters, who insist in this city on the use of the automatic switch or cut-off switch on the handle of the iron, which makes the iron cumbersome and expensive. The underwriters are fortified by the following clause in the National Electrical Code:

"An approved automatic attachment which will cut off the current when the iron is not on the stand or in actual use is desirable. Inspection departments having jurisdiction may require this provision to be carried out if they deem it advisable."

There is, however, an inclination on the part of the underwriters in New York to do away with this rule. Doubtless its removal, making a cheaper iron available, would go far toward breaking down the barriers.

An Attractive Field for the Electric Motor

THE replacement of steam-driven machinery by motor-driven equipment has long ago ceased to be exceptional practice, but there are still many installations of an industrial character in operation which have for some reason failed to take advantage of the electric drive. Among these may be cited the coal towers on the water fronts of popular communities. The great majority of these outfits are at present run by steam engines of a wasteful type, and it is not uncommon to find steam-driven hoists in active service in even large modern electric generating plants.

The disadvantage of the steam-driven coaling tower are many in view of the possibilities of electricity in the hoisting field. In the first place, to transmit high-pressure steam over the distance usually obtaining in coaling establishments, entails a loss from condensation, which is greatly increased in cold weather. Often it is necessary to transmit live steam two or three hundred feet from the central boiler plant to the hoisting engines, and in most cases this means a serious loss of steam-pressure, as well as increased fuel consumption.

In a typical plant of this sort there was recently noted a drop in steam-pressure of about 12 lbs. between the boilers and the engines; the piping was poorly insulated, so that the operating deck of each tower was almost unbearably hot when hoisting was in progress; the engines were of the simple non-condensing type, little better than so many open vent pipes in point of steam economy; the entire installation was covered with grime, and the labour item in the work of hoisting exceedingly heavy. Two men were required at the hoisting and trolley traverse engines, a third guided the grab bucket in the descent and ascent from the barge in the slip, a fourth fired the boilers, and a fifth operated another simple engine, windlass and coal slide used to move the receiving cars back and forth upon the wharf and supply them with fuel from the pocket above.

Given a well-designed motor-driven installation, there would be no transmission losses whatever when the machinery was not in operation; the losses at any time would be simply in proportion to the load being handled when the current was on. In place of the shocks and strains imposed by the engines upon the tower structures, the stresses would be proportionally reduced to the less violent and steadier motor torques required; or, with the same strain upon the towers, quicker acceleration and hence greater capacity would be the result. In place of the notoriously low efficiency of the donkey engine, the well-known maximum economy of the electric motor would reduce the fuel cost of operation probably from 25 to 50 per cent. at least; and in a well-designed installation one of the hoisting engineers could be dispensed with on each tower if a proper use were made of the remote control principal.

With suitable cable connections, buttons and switch relays in front of the operator, the control could be exercised from any point of advantage along the wharf, at the side of the tower, or even from the barge deck itself if that should prove to be desirable. The machinery room could be kept clean and comfortable, and all the benefits of flexible lighting could be had with an electrical installation. Instead of the 50 per cent. excess boiler capacity required to supply the condensation and radiation losses and operate the donkey engines, with electric motors the margin would be perhaps 10 or 15 per cent., releasing 35 to 40 per cent. of boiler capacity for other duty or expansion of plant in an established installation, or calling for perhaps 35 per cent. smaller original boiler plant investment in a new coal-handling installation.

Considering the record which the electric hoist has made for itself in mining installation, where the conditions are far more severe than obtain on the wharf of a coal-handling plant in a settled community, there ought to be no great difficulty in adopting it to coaling-tower service on any water front. There is room for the design of better controlling mechanisms, perhaps along the line of the switches used in multiple-unit railway equipments, and if the motor-driven plant is to earn a good name, ample motive-power must be supplied for the work in hand. The electric crane needs but slight alteration, in many cases, to fit it admirably to coal-hoisting service.

Central Station Rates

NO problem of greater importance than the rate question confronts the central station industry at the present time. The retention of established business and the securing of new customers depend in the last analysis upon the prevailing rates, and unless these are equitable to both the company and the customer, money and effort devoted to comprehensive advertising and organized solicitation are certain to be inefficiently expended.

It is often the case that the public fails to realize the justice of widely varying changes to different consumers of electric light and power, accustomed as it is to flat rates on water and gas. Even if the consumer appreciates that the difference in conditions between one city and another justifies a wide difference in rates, it is a much more difficult problem to make it clear to him that there is good reason why the rates in a single community should vary.

One thing that is certainly clear is that nothing short of an open, frank attitude in regard to rates can disarm unjust suspicion on the part of the public that the rates are unfairly made and applied. It is vitally important that a maximum rate should not be fixed by law, but unless central station men everywhere join hands in making the equities of the rate problem clear to dissatisfied customers and inquiring legislators, serious restrictions are liable to be imposed at any time. The review of rates by a state commission is far more elastic in its possibilities of change as conditions alter than the prescription of a legislative maximum.

At the July meeting of the Association of Electric Lighting Engineers of New England, held at Springfield, Mass., the rate problem was discussed in an unusually frank spirit. It was pointed out that nothing is to be gained by shutting one's eyes to the attitude of the customer in regard to wide differences between lighting and power rates on current generated at a single plant.

It is natural enough that a lighting rate of 15 or 18 cents per kilowatt-hour should be looked at askance by the customer when a power rate of from 5 to 3 cents or even lower applies on the same system. It will not do to point out that this condition is found on other systems as the sole reason for its existence. What is essential is to frankly point out the differences and the reasons therefor somewhat along the following lines:—

Without going into all the intricacies of sliding scales and step rates, it should be clear to every customer that the business department of an electric light and power company can present wholesale rates to the large consumer just as fairly as the transportation company can offer a lower rate on carload shipments or the retail grocer sell flour cheaper by the barrel than when small quantities are purchased. Thus, in a water power electric plant, the small consumer may have to pay 5 cents per kilowatt-hour against possibly 2 or 3 cents on the larger customer's bill.

The wisdom of granting discounts bringing the rates, even on large consumptions, as low as 2 or 3 cents, is open to considerable debate, but that is a question aside from the present issue. If the small consumer complains that his larger competitor has an undue advantage by virtue of the lower rate which the latter enjoys, the answer must be that such a condition is the inevitable result of pitting small means against large in every department of commercial activity. There is some mitigation, however, in the fact that the cost of power and light seldom exceed 5 or 10 per cent. of the total cost of manufacturing a commodity, since labour and material charges constitute the great result of the expense.

The electric light and power industry differ radically from the gas industry in one important particular —the difficulty of strong power economically to meet the demands of the peak load. The storage battery is a most useful adjunct of many a power station, but compared with the gas holder it is naturally an expensive and relatively inefficient apparatus. Hence a large capital must be invested in reserve equipment in an electric plant, in order to properly carry the peak load, and this is true regardless of whether water or steam power,—or even gas engine power—is employed to drive the generators. As soon as the customer realizes this point, the justice of the "readiness-to-serve" charges ought to be easily apparent.

Finally, there is a broad difference between the supply of light and the supply of power which justifies a considerable, though possibly not an excessive, difference in rates, even when power and lighting current is drawn from the same bus-bars. This difference lies essentially in the simultaneous demand for light at all points on the system and the varying demands for power throughout the day.

Probably at no time is the demand for power as universal, taking all the customers into consideration, as the demand for lighting current. The relation of the peak to the non-peak load enters this question with force. By special rates and contracts it is sometimes possible to keep down the peak load in the winter season through the expedient of limiting low-rate power service in certain cases to non-peak hours. As a matter of fact, it is probable that in plants where the equipment has been co-ordinated to a common bus-bar basis of supply, the rates for power and lighting current in the future will not be as far apart as they have been in the past. Whatever may be the rates in force, there is little doubt that a fair published schedule is in the long run the wisest policy.

The Present Status of the Electrolysis Situation

To the Editor of The Elctrical Age:

Dear Sir:—I have read the article entitled "The Present Status of the Electrolysis Situation," by Prof. Caldwell, and take the liberty to make a few comments on it.

Among the "certain well-established facts concerning electrolysis" which are stated, there are a few which may be considered which are often met with in practice. As to the statement relating to the bonding of lead-covered cables to the track return, it is well known that this method has been practiced for a number of years, and is really their only protection against electrolysis. It is not stated, however, that such bonding has another effect which causes electrolysis upon other adjacent metals in the same street as the cables, such as water and gas pipes. This is dangerous to such metals close together in the ground,—often crossing at street intersections,—the pipes becoming "positive" to the cables and being destroyed. Recent examinations by the writer has proved this to be the case in several instances.

This same effect applies to the bonding of water mains to track returns, causing the gas mains to suffer, or vice versa. In fact, the trouble is not ended by simply bonding one or two underground systems.

The method of keeping the drop in the track return as low as possible by the use of first-class rail bonding and by the application of return feeders, is spoken of as the "generally accepted policy." We do not find this to be the case, except in large cities. In many cases to-day there are trolley lines operating which in their unbonded state are simply a disgrace. One recent instance shows a gas pipe positive to rails near a power house of from 10 to 30 volts. The life of the main at such a point is about one week. This may be considered unusual, but it serves to show the indifference displayed on the part of some railway companies on this question.

Reference is made to "a regular feeder and main system" similar to the Edison three-wire system, which, it is stated, is "often advisable." This method is not new, but there are objections, such as maintaining high voltage at certain points and unequal load pertaining in a movable system like a railway, as against the stationary lighting system. Besides, it not being adopted anywhere would act as a reason for not recommending it as "often advisable."

The double trolley has been in use for a number of years, and is known to be practicable, the Government of Japan, it is learned, having recently adopted that system for cities in that country.

Insulating joints are spoken of. This method has found favour in some cases, and is a detriment in other cases. Where cement joints are used, as in cast-iron gas mains, in place of the lead joint, very little current will flow except in severe cases. Where such are in the same streets as water mains, it will be found that the water main will carry the burden.

The question, in our opinion, will long be a serious one, where immunity from electrolysis with the single trolley depends upon the voluntary action of the average railway company in establishing such nice conditions as perfect track returns and constant maintenance of them. Prof. Caldwell seems to think that practical immunity from electrolysis would then obtain. I think, however, that to constantly maintain such ideal conditions is impossible. Hence vigilance is the word while the single trolley is with us.

Yours very truly,
A. A. Knudson.

The United States Navy Department is to establish on the Pacific Coast a system of wireless telegraph stations similar to that on the Atlantic Coast. Stations are now at San Diego, Arquello, Farranola and Mare Island. Those to be established will be at Table Bluff, Cape Blanco, North Head and Cape Flattery. The distances between stations vary from 130 to 210 miles.

A portable wireless telegraph set, weighing about 300 lbs. is to be tested by the United States Signal Corps. The set can easily be packed on two mules.

Electrochemical Processes as Central Station Load Equalizers

By E. A. SPERRY

A Paper Read at the Recent General Meeting of the American Electrochemical Association

FOR some years the station manager, the electrochemist and the electrometallurgist have been groping for each other. For some reason there is a notable lack of any union of interests of any electrochemical process deriving its supply or utilizing equipment of the central station. Papers have been read and much said as to the possibilities of this combination, which, however, does not seem to materialize.

Some time ago the author undertook some investigations as to the exact conditions existing with some central station managers and what terms they were willing to make as inducement to the establishment of permanent electrochemical loads of more or less magnitude. Our prime requisite with electrochemical processess is cheap and centrally located power; and many of these processes may easily become large consumers of power.

The question naturally arises, why is it that this combination has not been brought about, as earlier expected. The result of observations and of such time as the author has been able to devote to the question has been that neither party has yet by any means exhausted this subject, and, furthermore, that some misunderstanding exists as to the conditions which are capable of being so harmonized as to yield commercial results to both.

The condition is growing more favorable in that the central station manager is constantly gaining knowledge and experience as to the value and relation of certain factors in this load curve, and something as to what it means to him to have the valleys filled, portions of his load equalized, and the mean load increased.

We hear much about the evils of the peak in the station load curve; the peak in the load curve is only a relative matter, and there are managers who still think that the disadvantages of peak load is a matter of altitude of the peak. It is not at all so; on the contrary, it is only a matter of prominence above surroundings, and its evil is in its height in relation to mean load. The peak represents the investment, while mean load represents receipts. Anything that brings up the latter, contributes directly to earning capacity and (a point which is not generally recognized in connection with this) is almost wholly independent of the rate received for the additions if they are rightly placed on the load curve.

Another favorable sign is that managers are becoming more and more keen for business, and, as their stations increase in importance, are able to make concessions and inducements for loads impossible a few years ago, and in many instances are willing to make very low rates for "off-peak" load. The operations of the stations vary through quite wide limits as to the hours and seasons which they can furnish current falling strictly within this class.

With the very closest prices that have been named, the station manager, has, in some instances, demanded the emergency privilege of cuttting off the current always with notice, unless absolutely impossible, and, in one or two instances, the price has been made on a sliding scale, based on the price of fuel. In connnection with this last item any long-time contract should include considerations relative to the conversion factors or the thermal efficiency of the prime movers employed in such a way as to properly cover the actual fuel factor, as represented in the power cost, in the mutual interest of parties concerned.

The hours and seasons available in various stations fall within three classes, the most favourable being a guarantee of twenty-four-hour power for ten months of the year, approximately, or forty-three weeks; three weeks, twenty-two-hour power; and six weeks, twenty-hour power; during these two latter periods guaranteeing forty-hours' continuous power at the weeks' ends. This gives a full year, less 180 hours, or about 98 per cent. available time throughout the year.

The second class grants twenty-four hours during about nine months of the year, or thirty-nine weeks; six weeks with twenty-one-hour power; and seven weeks with nineteen-hour power; guaranteeing during these two latter periods thirty-eight-hour continuous power at the weeks' ends. This class yields 96½ per cent. of all available time.

A third class demands a two-hour peak for six days each week, during which no power is furnished for ten months, or forty-three weeks of the year, and a four-hour peak during the remaining nine weeks. This class is willing to guarantee throughout the year forty-hour continuous power at the weeks' ends, which yields 92.6 per cent of the total time available.

Some station managers, especially those of the first class, go so far as to say that if they assume the load they will, in all probability, carry it more hours than guaranteed. Others, again, go so far as to intimate that they will find some way in which to carry it all the time, especially days when their battery is not unduly drawn upon. In every instance the cost will go higher if the energy is required to be transmitted to a distance, and the site for the electrolytic plant should be chosen accordingly.

It may be stated as a general proposition under these conditions, where the electrolytic load is available to equalize the station load, that power is available for electrolytic work in large units at equal rates, if not more favourable than those ruling for water power. Where the process is one that does admit of interruption, storage is, of course, always available, where the extra cost entailed permits its use.

There are conditions under which the additional power cost entailed need not be great, and from the standpoint of the central station manager a storage battery is a most desirable adjunct. This arises from the fact that while its discharge is confined to short and definitely placid periods, its charge may go forward at periods entirely conformable to the demands of the station for equalizing purposes, while its economical rate of charge may be varied through exceedingly wide limits, therefore, available for the most economical loading of the generating units.

In some electrolytic processes the current may be dropped to a mere fraction of normal intensity, and, in this way, a comparatively small storage battery may be employed to carry the process over the cut-off periods.

Intermittent processes, or those susceptible of interruption under commercial conditions, are desirable in this connection. The electrolytic and electrothermic arts by no means abound in processes that may be considered commercially intermittent. It is expected that this condition will gradually change as the advantages of centrally-located, abundant and cheap power are brought more into prominence; this is evidently the duty of the station management having problems of load and equalization before it.

On the other hand, the electrochemist and metallurgist should be none the less active. In fact, it would seem that his task is the greater. Processes that are applicable must be brought out, thoroughly tested, under conditions of service proposed, and demonstrated to be thoroughly practicable and commercial.

Electric Motors for Driving Mine Pumps

IN discussing electric pumping in collieries, in a recent paper before the Manchester Geological & Mining Society, G. H. J. Hooghwinkel said that the pumps should be driven by high-speed, three-phase motors, because they were the cheapest and best adapted for mining purposes and might be worked up to an output of 100 H. P. without a starting switch. Instead of the latter, it is equipped with a centrifugal compensator, which can be made completely gas and water tight, and which cuts out the starting resistances automatically.

The point is to construct a motor running at a medium speed, and well ventilated so as to show no high temperature use after a 24-hour run. Another requirement is the possibility of regulating the position of the stator of the motor, as the small clearance between the rotor and the stator with three-phase motors (continuous-current motors are not very suitable for underground pumping) soon necessitates a readjustment of the clearance, after continuous running, perhaps for months, without stopping.

For large motors, it is essential that they be constructed in many parts, so as to permit of easy transport in the shaft and narrow roadways. Motors of a capacity of 200 H. P. and more should be provided with slip-rings, and these can be completely enclosed, so as to be water and gas tight. They must be so well ventilated that, after continuous running for any considerable length of time, their temperature limit is not reached.

A three-phase motor of modern construction may be considered free from breakdown, and it is therefore not necessary to provide spare units. It is good practice to mount the motor between two pumps, one being a spare, or between the two cylinders of a two-cylinder pump. Direct driving, although not absolutely necessary, is to be preferred, especially for large sets. If gearing is used, bronze wheels and raw-hide pinions should be employed in order to avoid noise, which is most objectionable in a mine, and constitutes a real danger.

The motor may also be mounted side by side with a three-cylinder pump, but this arrangement has the disadvantage that all parts of the pump are not so easily reached as with the motor placed in the center. In the former case, however, the motor should be provided with a revolving mass, either in the rotor or in the shape of a separate fly-wheel, so as to ensure an even turning moment.

Of course, where existing slow-speed steam pumps have to be converted into electrically-driven pumps, special motors must be built, and this sometimes necessitates very special designs. In a case within the writer's experience, a steam-driven pump, making 68 revolutions per minute, had to be converted by replacing the steam cylinder by a 150-H. P. three-phase motor, working at a periodicity of 21 and therefore requiring 38 poles. This again required a large stator, which had to be especially stiffened by means of end-shells, so as to ensure safety from breakdown with a clearance of only 0.07 inch.

Specially stiffened frames, however, are very expensive, and a very small clearance is in every way undesirable from a running point of view. This may be avoided by using a motor with a double armature, having about half the diameter of an ordinary slow-speed motor, but more than double the length, which is no disadvantage. Two rotors and two stators are placed next to each other and combined into one. Each stator and each rotor has, therefore, half the normal windings and half the number of poles.

This construction has still another advantage. We may cross-connect, or rather exchange the electric junctions of the one rotor for the other stator winding, as follows:—

The right-hand rotor winding is connected directly to the left-hand stator winding, both forming, therefore, a short-circuited winding without slip rings, and may be former wound. The second half of the secondary winding is on the right-hand stator and may, therefore, be ended at fixed terminals. The stator may be connected to a three-phase starter. The motor has, therefore, no slip-rings, and is eminently suitable for use in fiery mines.

Much depends, of course, on the regularity of the pumping. If the flow of water to be removed is constant, then the pumps can be run direct from the mains of a power station. In small pumping plants, if the flow varies very much, the pumps may stand idle during the hours of less flow, but with large installations this is hardly practicable. In the latter case, the pumping plant must have its own electric generating plant at the power station, namely, its own dynamo and spare plant, so as to regulate the speed of the pump by influencing the generator field through a separate exciter, and also the steam-engine speed. This ensures a speed regulation without incurring the losses of a speed-control through resistances. This arrangement is only, however, to be recommended for large pumping plants (300 to 500 H. P.) as the generator units in the power station will be about that size.

In both cases, however, employing either a separate dynamo or direct driving from the mains, there should be a starting arrangement in the mine as well, and the motor should be provided with slip-rings. In case of emergency, the man in the pump room should not be obliged to ring up the power station, but he should be able to shut down the pumping plant himself. A telephone should always be installed between the pump room in the mine, which is used at the same time as a general distributing room for the electrical energy, and the power station on the surface.

Books on Electricity

A LIST of books on electricity contained in the Pratt Institute Free Library, Brooklyn, N. Y., is being mailed to any address on receipt of a request.

The list was prepared in 1905 by Herbert L. Cowing, then head of the Applied Science Reference Department of the Pratt Institute Free Library. Annotations are given for each book, and these, as far as possible, have been made from the point of view of the student or user of books who is without special training in electricity. The net price of each book is given in almost every case.

With the exception of electrotherapeutics the subjects treated of by the books listed cover practically every branch of electricity.

The British rights for the patents of the Thury system of high-tension direct-current transmission have been purchased by Dick, Kerr & Company. This system of transmission is said to be under consideration for London power supply.

Increasing Business in a Small City

By SAMUEL RUST, of Greenville, Ohio

A Paper Read at the Recent Convention of the Ohio Electric Light Association

THIS subject is a very interesting one to every electric light manager or superintendent, and while it is not the writer's intention to try to cover all of the ground, he will give some of his personal experiences and ideas in trying to secure and maintain a business in a small town or city where the field for new business is limited and where it has been intelligently worked for many years.

In the first place, you will all agree that we must give good service, and in order to do this the manager or superintendent must have reliable men—men who take pride in their work and who make the company's interest their interest. They must be men that are trustworthy, and if any of them have to deal with the customers (and they all do more or less), they should be courteous at all times.

I believe that the central stations should take care of all construction work, such as wiring, etc., for the customers; at least, the company should see to it that the contractor does not charge prices that will tend to prevent prospective customers from installing the wiring; in fact, any work of this class should be installed by the lighting company at nearly cost. In doing this the company should of course use nothing but the very best material and workmanship. The manager or superintendent should make it his duty to convince the customers that the company is giving them value received for everything done for them, that it is his earnest endeavour to favour them as far as it is possible, and never under any circumstance misrepresent anything. It is far better for your business if you never secure a man for a customer than to get him and lose him because he finds that you have misrepresented something.

I believe that every central station should furnish free renewals, no matter how small the town. It has a pleasing effect on the customer and I believe it a paying business for the company, for the reason that if the customer is compelled to pay for his renewals, you will find him taking lamps from places that are little used, leaving the sockets open, and when he has occasion to use light in these places, he does without. This works two hardships on the company; first, the loss of the current consumed; second, the dissatisfied customer, because he has to use some other kind of light, and perhaps go to some inconvenience in order to accomplish his purpose; whereas, had there been an electric lamp there, he would have turned it on and been pleased with the result.

The successful superintendent in a small town, must, of necessity, be a very busy man. He must be in touch with everything, from the coal pile to the lamp. Must know where his men are, what they are doing at all times, be with them as much as possible, and know that the work along every line of the business is being done in the most economical and best way possible. He should make a study of his customers, know their peculiarities, and see that they are taken care of in a way that will satisfy each individual. It is a deplorable fact that almost every public service company has the reputation of overcharging and mistreating their customers. This feeling may be, and should be eliminated, and I believe that this duty falls upon the shoulders of the superintendent, perhaps, more than any other officer of the company, and by hard and continuous work, by meeting the customers from time to time, listening to their grievances, whether they be real or imaginary, yielding to their whims as far as possible, and constantly bringing before them and impressing on them the fact that their interests are your interests, you can convince them that you are their friends, and that you are serving them rather than trying to overcharge them. Whenever you succeed in gaining their confidence, you will have a friend as long as you prove worthy of their friendship, and that customer will do you more good in getting new business than any one you might hire.

Another grave mistake that is made by many small plants, is the arbitrary way they have adopted of furnishing service. Some have certain hours to run, starting at a given hour and shutting down at a certain hour. Others are controlled by the weather, starting when it gets dark and stopping as soon as they think it is light enough to do so. I have found that these things are very annoying and unsatisfactory to the customer. He may have a dark store and will need light, when the majority do not need it and you may shut off the light just at the time when the consumer may have an important customer. Now, put yourself in the same place and see how long you will put up with that kind of service. The current should be kept on the lines as much as possible. You may not make anything in dollars and cents; in fact, you may lose something in operating during the day, but I am sure that the satisfaction will more than recompense you for any outlay that you may make in this direction. The revenue derived from this service may not look like a paying proposition; in fact, it may appear that you are losing by operating your plant at times, but the fact that you are giving satisfaction and that your customer can have what he wants and at the time he wants it, will more than repay for the seeming loss in operating. This kind of service opens up a field for many little things that are a convenience to the customer and incidentally a source of revenue for the company. It gives you a chance to install sewing-machine motors, flatirons, chafing dishes and a great many other things that are fully appreciated by your customers.

Another thing that is in favour of the continuous operation of your plant is the fact that you may educate the public to use more light. If they know that they can use it at any time, they will learn to use it at times when ordinarily they have been getting along without it. The fact that they know that they can have the use of the current will tend to have a pleasing effect upon the customer and you all know what that means, not only more revenue from these parties but their influence towards securing other and new business from their friends. This is the end for which we should all be working. The satisfied and enthusiastic customers are the best advertising mediums that a company can secure.

The inducements of good service, courteous treatment, free renewals and day current will do much to solve the difficulty of slow business, but where this does not bring in the necessary amount of increase desired by a company, special inducements may be employed in some cases to good advantage. Where the company has a day current, and I believe that no company should operate without furnishing a day current, special inducements can be offered that will attract residence customers especially. I have always found that where you could enlist the interests of the ladies in your business that you had a strong aid if the inducements were such as to appeal to their ideas of good house-keeping and labour-saving devices. With a day current flat irons can be made to prove a profitable investment, not supplied free, because I have always found that what costs nothing is usually but little appreciated, but supplied at actual cost installed without further cost than the iron. The best method of introducing the flat-iron problem is to order plenty, get consent to install on trial, say nothing about price or cost until they have had a chance to get acquainted with their use. Where irons are furnished at cost, it will be found that less than five per cent. will come back to the plant when the time comes to close the contract or remove the irons.

The same rule holds good as to water heaters, sewing-machine motors, small radiators for bedroom service and other like appliances costing little but adding greatly to the convenience of the household.

One hard problem I have found in pushing residence business has been the immediate cost of wiring in houses that are already occupied. I have not tried collecting for wiring in installments but I believe that such inducements will be profitable. Where parties are absolutely good I have found it to an advantage to give all reasonable time asked for in paying for wiring. Another inducement is to offer free a nice portable lamp in each residence wired. This does not partake of free wiring but is merely an evidence of good will on the part of the company to induce the customer to stand the inconvenience of having the house wired. I believe that companies could advertise this as a special inducement for certain months and it would bring in much more than the cost of the lamp. With business houses I have found that furnishing the newest and best method of lighting is an inducement that is always good. In the plant with which I am connected, we would have lost three very desirable department store customers had we not been able to please them with the high efficiency lamp, and while they paid for the first installation, all lamp renewals are furnished under the contract. This was sufficient inducement in these cases. I have also found that in small stores where they were dissatisfied with a small installation of lamps or with the use of gas, that the installation without cost of high-efficiency lamp would bring about satisfaction, or a change of gas to electricity. No matter how small the town or how unprogressive the business man, if he sees his competitor well lighted and drawing customers for that reason he will listen to inducements for his own lighting.

As I before stated, the necessity for the superintendent or business manager of the plant in a small city or town to know and have a business acquaintance with all light consumers, is an absolute necessity. Five minutes, two or three times each month, spent in the store of a man who does not use your product, with inducements of better light, will eventually get his business.

One of the greatest mistakes some of the smaller central stations are making and perhaps the primary cause of many plants not proving a financial success is the system of selling current on a flat rate basis. Many times a superintendent in order to secure business will listen to a prospective customer as to how much current he will use and the hours that he will use it, and basing his calculations on the customer's statement makes a price too low and in a short time finds the same customer using fully double the current he had contracted for. In this case you have no recourse other than to shut him off, making an enemy who will knock your business afterward, or letting him continue at a loss. To any superintendent labouring under such unfavourable conditions I would say:—Do not sleep after you return home until you put all your customers upon meters, for this is your only salvation. You may hesitate fearing you will lose some business; you may, but the probabilities are you will not lose any if they are properly handled; even if you should lose a few, don't worry, as the ones you lose will be the ones that you cannot afford to keep on your lines.

The first thing to do is to find out as near as possible what your current costs to produce and then add to that a fair profit, bearing in mind that you are to now get paid for all you put out, and make your rate as favourable as possible to the customer and never lose sight of the fact that your rate must be one that the consumer can afford to use the current, not as they have been using it but as they need it and as it should be used.

If you have the confidence of your people it is not a hard proposition to convince the average business man that you are giving him all that you can afford. With this change you will find that the gross earnings of your plant will increase very materially and at the same time your output and operating expenses will decrease. I am not giving you theory but experience. The plant with which I am now connected has within the last two or three years gone through this same experience and while I was not with them during the greater part of this change, I know it was a most satisfactory change to both company and customers. In making the change to meters, they adopted the two rate system for stores and commercial use, giving the customer the option of the two rate or straight meter system. They went into the question of the cost of production and fixed expenses very thoroughly in order to arrive at the best price that they could give the consumer. They then went to their customers giving them the reasons for the change, and courteously but firmly informing them that the flat rate system was to be a thing of the past, that current would only be sold by meter and that they might have their option of either current at a 9 cent rate including the discount, or a two rate system with a fixed charge of $3.00 per K. W. per month and current at a 4 cent rate, or the company would be compelled to discontinue service.

No attempt was made to withhold anything from the customer and the whole matter was dealt with by a heart-to-heart business talk on the injustice of flat rate system and the necessity for the meter rate which would be fair to both parties to the contract. In a city of 7000 people not a single customer was lost in changing over and the results have been better satisfied customers, more light used, larger receipts for the company, less operating expenses and more actual profit from the business done.

I do not believe that our company or our city is differently situated from any other company or town or city in the State and that the same results could be obtained and a surely profitable business had as against a poor business at an unsatisfactory rate under the old flat rate system.

To recapitulate, I will say that the following will increase business in any town:—

Reasonable meter rates, good service, courteous treatment, good wiring at or near cost, free renewals, continuous service, attention to small details, cultivation of acquaintance, careful attention to plant, allow wiring to be paid for in installments or on reasonably long time, offer such little inducements in the way of labour-saving and comfort-giving appliances, as will enlist the interest of the ladies. At all times work to convince the people that the company is working in their interest.

Annual Convention of the International Association of Municipal Electricians

THE eleventh annual convention of the International Association of Municipal Electricians was held at New Haven, Conn., on August 15, 16 and 17. The meeting was called to order by the president, J. Murphy, of Cleveland, Ohio, at 10:30 A. M., and the Rev. Mr. Knight, of New Haven, invoked the Divine blessing. Governor Roberts, of Connecticut, and the Mayor of New Haven, Hon. J. P. Studley, then made addresses of welcome. Ex-Mayor Hendrics presented the Association with a gavel on behalf of the firemen of the city.

President Murphy then followed with an address and also read a paper on "The Advisability of Placing the City Electrician Under Civil Service Rules." In the discussion on this paper, most of the members agreed with Mr. Murphy in his idea that all should be under the rules. The decided opinion was expressed, however, that the majority of rules now existing were capable of great improvement.

After the reading of communications and the appointment of a nominating committee the morning session was declared adjourned.

At 2:30 P. M. the members took up the papers and reports relating to the electric light and power division of the association. The chairman, A. S. Hatch, of Detroit, read a report on the subject, which was discussed by Messrs. Smith, of Norfolk, Va.; Bradshaw, of Charlotte, N. C.; George, of Houston, Tex.; O'Hearn, of Cambridge, Mass., and Petty, of Rutherford, N. J. Mr. Hatch also read a paper on a proposed trackless trolley system for Detroit.

Questions in the Question Box relating to this department were as follows:—

How are "outs" reported and what record is kept of them? What notices are given the company?

Do you prefer mast arms or center suspension in order to put the lamp in the center of the street? With the former the lamp is not quite in the center and with the latter there are two poles instead of one in the street.

What restrictions are made in the disposal of broken globes and carbon stubs? How badly broken may a globe be before it must be changed?

What constitutes dark and moonlight nights? If the night is cloudy though moonlight, can you compel the lights to be turned on?

What methods are adopted to know the company is furnishing full current to the circuits?

Answering the reporting of "outs," the prevailing method was to have this done by the police department, the public supply companies keeping men on duty to trim lamps when the report was received from a patrolman.

Mast arms, in cases where the trees were not heavy, were considered better than center suspension. Where the foliage was dense, as in suburban towns, it was necessary to suspend lamps from the center of the streets.

Broken globes should not be thrown in a nearby lot, as is often done. Trimmers should be fined if detected doing this.

Most towns favoured the full burning schedule, but where the Philadelphia moonlight schedule was in force, provisos were inserted calling for the lighting of the streets upon short notice.

Measurement of the wattage of circuits was considered the only proper manner of ascertaining that the city was receiving full candle-power in its lamps.

Matters relating to the inspection department were taken up at the evening session, when a report was made by T. C. O'Hearn, the chairman. In his report, Mr. O'Hearn reviewed the work of the code committee and spoke of the advisability of adopting local rules in addition to the code wherever necessary. He did not favour any alteration of the code, as it was the result of the work of the ablest minds. This report was followed by the reading of a paper entitled "Conditions Surrounding the Inspection of Wires in the Southwest," by C. R. George, of Houston, Tex.

Mr. Smith, of Norfolk, in discussing the paper and report, gave several rules in force in his city, among them some which imposed fines on carpenters and other craftsmen who disturbed wires while working in buildings. This was considered an excellent idea by many present. Several others discussed the paper and the Question Box was then taken up. The questions relating to inspection were:—

What restrictions are placed on running services, particularly telephone and electric light services, from distributing poles in the center of the block with both classes of wires radiating in all directions, interlacing through each other?

What restrictions are placed on leakage of current from railway tracks to water pipes and what records are kept of such leaks?

What are the restrictions made concerning wires strung on buildings?

Who trims the trees, and what are the rules governing it?

Do any cities have an ordinance permitting or compelling pole lines being put on lot lines instead of streets and alleys, where there are no alleys, or where they run in the wrong direction?

Answers were received from several to these questions. Some cities placed restrictions on wires and poles, while others apparently had no rules governing the matter. The same answer was given to the restrictions concerning the leakage of current from railway tracks. It was stated that no more than 5 volts should show between the rails and cables and pipes. Some cities required constant tests and reports from the railway companies. Richmond has trees trimmed by a capable city nurseryman, who made such trimming as was necessary in a scientific manner.

The report on aerial construction was made by Will Y. Ellett, of Elmira. Mr. Ellett reviewed the latest methods of overhead wiring, and said the tendency was for a much better class of work all through. Messrs. Gascoigne, of Detroit; Bradshaw, of Charlotte, N. C., and others discussed the various methods of wiring, pole setting, and the attaching of police and fire-alarm boxes to the poles. The modern practice required running of ½-inch conduit to the top of the pole, rather than to the dropping of the wires to within a few feet of the box, as was formerly done. Instances were given of places where very careless construction had resulted in injury to the public.

The topic for the morning session of the 16th was underground construction. Louis Gascoigne, of Detroit, Mich., made a report on the subject, and a paper by W. H. Thompson was read and discussed. Mr. Thompson's paper was entitled "Comparison of Underground and Overhead Construction and the Relative Values of Single Rubber-Covered Wire and Lead-Encased Cable."

The discussion of the report and paper brought out interesting facts relating to the subjects. A question, "Is it not feasible to have a combined sewer and subway system, owned by a municipality, the subways to be rented to the public supply corporations?" brought out the opinion that such a scheme was not feasible.

The evening session was opened by J. B. Yeakle, of Baltimore, Md., who made a report on fire and police telegraph progress during the year, and also read a paper on "Details of Certain Auxiliaries to Fire-Alarm Apparatus."

The point brought out by Mr. Yeakle relating to the illumination of fire and police boxes at night was considered valuable, and it was stated that many towns are following the practice. A paper by Adam Bosch, of Newark, N. J., giving a history of the fire and police telegraph of this country, was read by title.

The Friday morning session was devoted to business. Norfolk, Va. was selected as the next place of meeting. The nominating committee made a report and the following were duly elected officers for the ensuing year:—

President, T. C. O'Hearn, Cambridge, Mass.; first vice-president, James Grant, New Haven, Conn.; second vice-president, C. R. George, Houston, Tex.; third vice-president, J. Berry, Indianapolis, Ind.; fourth vice-president, W. H. Bradt, Troy, N. Y.

Executive Committee:—A. D. Smith, Norfolk, Va.; J. B. Yeakle, Baltimore, Md.; Wm. Crane, Erie, Pa.; Jerry Murphy, Cleveland, Ohio; W. M. Petty, Rutherford, N. J.; A. S. Hatch, Detroit, Mich.; W. H. Thompson, Richmond, Va.; G. F. MacDonald, Ottawa, Can.; secretary, Frank P. Foster, Corning, N. Y.; treasurer, C. H. Diehl, Harrisburg, Pa.

Finance Committee:—L. W. Kittridge, New Haven, Conn.; C. E. Bradshaw, Charlotte, N. C.; W. D. Clayborne, Savannah, Ga.

Radium and Electric Discharges

THE effect of radium in facilitating the visible electric discharge *in vacuo* was described by A. A. C. Swinton at a recent meeting of the Physical Society, in London. It has been shown by Edison, Fleming, and others that the passage of the electric discharge *in vacuo* is much facilitated by heating the cathode. More recently it has been shown that the passage of the discharge is still further facilitated by coating the heated cathode with oxides of the alkaline metals.

It is generally held that the efficacy of the hot oxides in this direction is due to their giving off negatively-charged ions or corpuscles. The author, therefore, decided to ascertain whether similar effects could be obtained by painting the cathode with radium, and as radium gives off corpuscles when cold, it was anticipated that it might not be necessary to heat the cathode. Using a continuous current up to 400 volts pressure, this was found not to be the case, the radium having no appreciable effect in producing a visible discharge.

When the radium-coated cathode was heated to redness, the radium was found to have a very marked action in facilitating the production of a luminous discharge. Experiments were made which proved that the mere presence of radium in the tube was insufficient to produce the effect, and, furthermore, it was found that the tube would allow only visible discharges to pass in the direction that made the radium-treated electrode the cathode, the tube acting as a unidirectional valve in the same way as do tubes with cathodes coated with oxides.

Experiments were also made without any heating of the cathode, but using alternating currents of higher voltages than were available in continuous current. It was found that using an untreated electrode it required from 800 to 600 volts to get a visible discharge to pass; whereas, using a radium-treated electrode, a visible discharge would pass with from 700 to 800 volts. The exact voltages required in each case were variable, but it was always found that a visible discharge would pass, using the radium-treated electrode, with about 100 volts less than when the untreated electrode was employed.

An Electric Furnace for Heating Crucibles

IN an investigation upon the production and properties of electrolytic iron and iron alloys, now being pursued at the University of Wisconsin, under a grant from the Carnegie Institution, it became necessary, says Dr. O. P. Watts in "Electro-chemical and Metallurgical Industry," to secure a means of melting iron with the introduction of a minimum impurity. From the high temperature required, some form of electric furnace seemed most suitable, and after several months of experimenting with both arc and resistance types, a very simple form of resistance furnace was adopted, and has now been in successful use for several months.

It consists of a rectangular brick box, into which the crucibles are set, crushed carbon shoveled in and packed around them, and the current turned on until the desired temperature is attained. The outside dimensions are:—Length, 54 inches; width, 28 inches; height, 26 inches. The height includes a cellular base consisting of two courses of fire brick set on edge.

As the furnace rests upon a cement floor laid on the ground this construction affords ample protection, but if the furnace were set upon a table, in any part of which wood were used, it would be necessary to place a solid layer of brick between the two parts of the cellular base, to check radiation to the table.

The material used in its construction is fire-brick, with a lining of a single layer of magnesite brick. This lining is necessary, as fire-brick is attacked by hot carbon, and is also melted at the temperature usually attained in this furnace. No cement was used in laying the brick, and none is necessary, but it would be advisable where a permanent furnace is desired, to put iron straps around the outside to prevent spreading of the side walls under the influence of repeated expansion and contraction. This will be done when it becomes necessary to rebuild this furnace.

The articles to be heated are bedded in a granular resistor with their lengths at right angles to the heating current, but with the difference that the articles—in this case, the crucibles—are placed in a vertical instead of a horizontal position.

Among the advantages of this resistance furnace for crucibles may be mentioned the following:—Low costs and simplicity of construction; the possibility of designing the furnace to heat any desired number of crucibles simultaneously. By adapting the size of a furnace to the amount of energy available, any desired temperature may be attained up to that of the destruction of the container for the resistor. Where linings must be used in the crucibles, their melting or vapourizing fixes the maximum temperature at which the furnace may be successfully used. The crucibles are buried in the source of heat, and hence are heated more rapidly, effectively, and probably more uniformly than in some other furnaces, as for example, in the arc furnace where the source of heat is on one side only. For heating a half-dozen crucibles at once it has proved far more economical of energy than the arc furnace.

Some of its disadvantages are:—The need of a variable voltage for the most satisfactory operation. It is, so far as developed by the writer, an intermittent furnace, and hence wasteful of energy. It contains a large mass of material other than the crucibles and charges, namely, the resistor, which must be heated to the maximum temperature attained.

Electrical and Mechanical Progress

Large Induction Motors

FOUR induction motors, the largest installed west of the Mississippi River, have been purchased for the equipment of the famous 10,000-ton concentrator of the Washoe smelter, a new portion of the $9,000,000 reduction plant of the Anaconda Copper Mining Company, at Anaconda, Mont. They were designed and built at the electrical works of the Allis-Chalmers Company, of Cincinnati, Ohio.

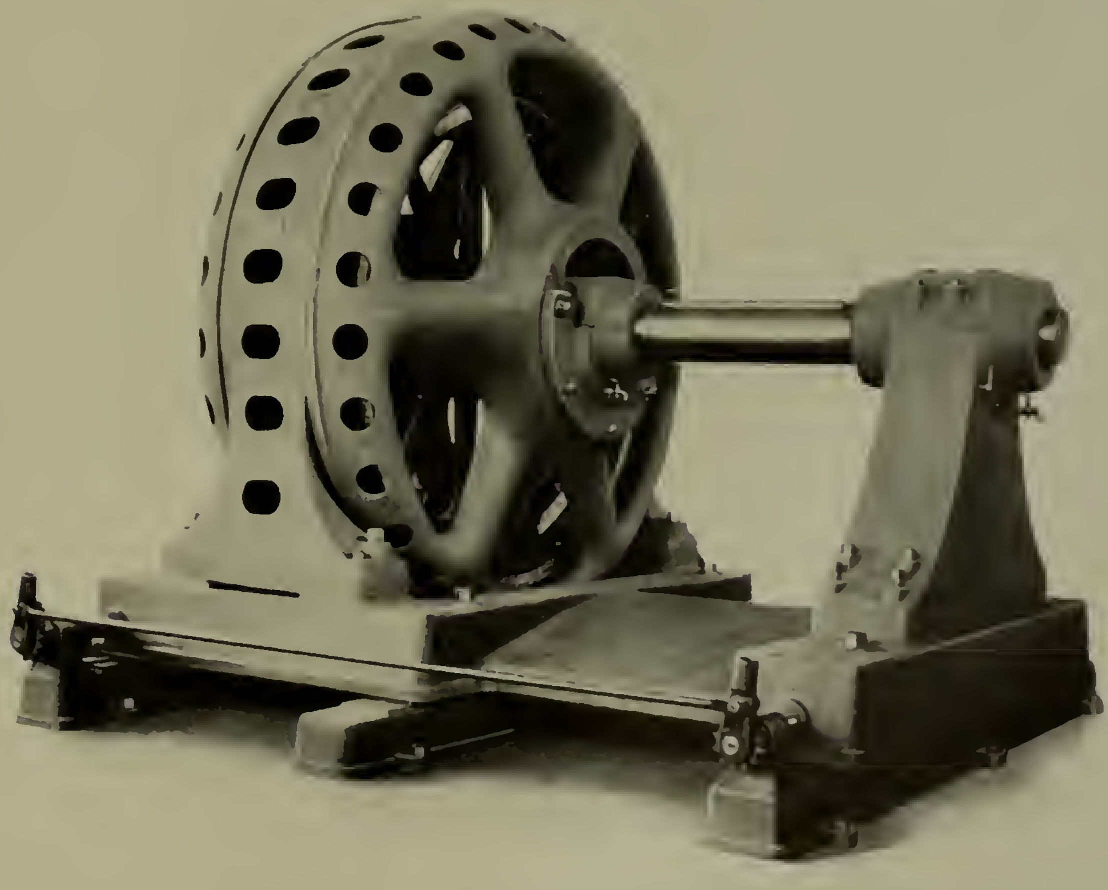
This plant is to operate with power supplied by the two stations of the Helena Power Transmission Company, on the Missouri River near Helena, nearly 100 miles from Anaconda. In addition to power being furnished for the smelter and street railway of Anaconda, the improvements now in progress will, when completed, make it possible for the mines of Butte to utilize Missouri River power.

The output of copper from the Washoe smelter, which has been equipped throughout with electrical drive, is from 15,000,000 to 17,000,000 pounds per month. Formerly all the power required was supplied by steam engines, and a certain amount of steam power will probably always be used, as some of the steam boilers utilize the heat contained in the waste gases from the furnaces. However, this power, obtained from a by-product, is not nearly sufficient to operate the whole plant, and all additional power is in the future to be supplied by electricity.

A second huge dam is being built across the river, near Helena, by the Missouri River Power Company, by which the waters will be backed up to form a lake near the capital city. The transmission of power will be at a pressure of 76,000 volts over a double line to Anaconda, nearly a hundred miles distant.

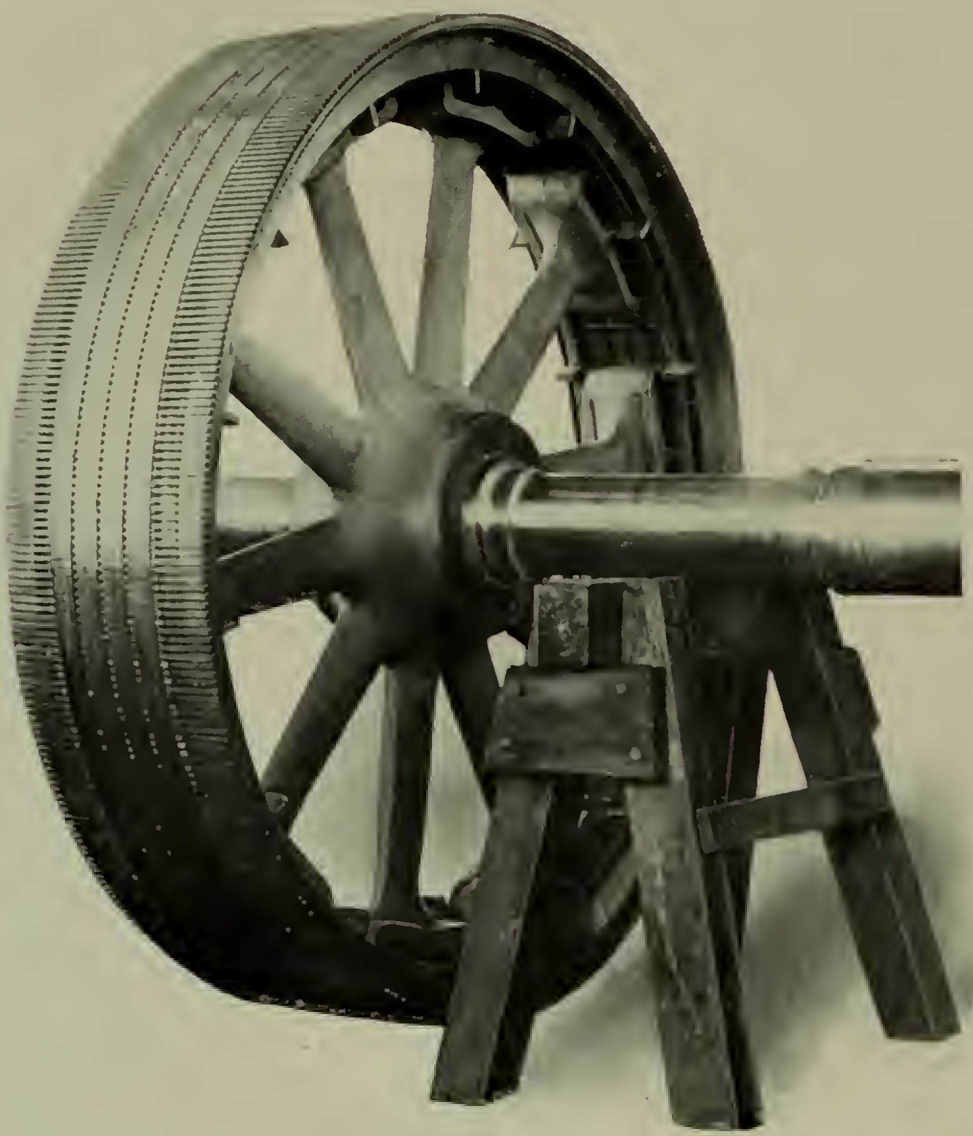
A sub-station at the smelter contains the step-down transformers for lowering the pressure to 2200 volts for distribution to the various parts of the plant. The Anaconda Company has also recently purchased a water-power plant located at Flint Creek, about thirty-one miles from the smelter, and capable of supplying about 1500 KW.; the power from this plant will be used principally for the operation of blowers and air compressors in the smelter power house.

The concentrating plant is the first unit to be driven by electric power exclusively, the four large induction motors being used for this purpose. The concentration building is 600 feet long, with the steam plant heretofore used for driving it located in the centre. The jigs, tables, etc., are driven from a main line shaft 500 feet long to which the



A 1200-H. P. THREE-PHASE INDUCTION MOTOR BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS., FOR THE ANACONDA COPPER COMPANY engines have been connected by rope drive and friction clutch pulleys.

It is intended to leave this steam plant intact, to be used as a reserve in case the electric power fails, and disconnect the shaft at each side where it enters the engine room, thus dividing the shaft into three parts, a live section on each side of the engine room. The mill, as a whole, is divided into eight sections, four on each side of the engine room. Two induction motors will be installed in each half of the mill, and connected to the main shaft by rope drive and friction clutch pulleys.



THE ROTOR OF THE INDUCTION MOTOR SHOWN ON THE PREVIOUS PAGE

Each motor has a 1200-H. P. output at 360 revolutions per minute synchronous speed, and will furnish power sufficient to operate easily two mill sections; connection is made to the main shaft by eighteen 2-inch ropes, and the pulley dimensions are such that the main shaft will be driven at 250 revolutions per minute.

These large motors, one of which is shown in Fig. 1, designed and built by the Allis-Chalmers Company at their Cincinnati works, are notable not only on account of their large size, but also because of their having squirrel-cage rotors,—something unusual in motors of this size. Their guaranteed full-load efficiency is 91 per cent., and their full-load power factor 92 per cent. Squirrel-cage motors were chosen for this installation because the conditions under which they have to start are favourable, and also because of the higher power factor of this kind of motor as compared with the wound-rotor type.

The motors being connected to friction clutches, start up light, and as the mill runs continuously, it is not expected that the motors will be started at all frequently. The power system of the Missouri River Power Company is so large that the occasional starting of one of these motors will not cause undue disturbance, while the higher power factor under ordinary running conditions is a decided advantage. Tests show that these motors exceed the guaranteed power factor of 92 per cent., and that the starting current taken from the line will not exceed full-load running current when starting the motor with its ropes and friction pulley connected.

Starting is effected by an oil-immersed controller connected to an auto-transformer which lowers the applied voltage at starting. The controller has six steps, so that the motor can be brought up to speed gradually. Since the motors are arranged in pairs in the mill, one controller is provided for each pair of motors, and the necessary instruments, switches, and the like, are mounted on two two-panel marble switchboards placed near the motors; the controller is operated by means of a hand wheel on the front of the board.

The main switches and also the transfer switch for connecting either motor to the controller are of the oil-immersed type, and are interlocked with the controller handle in such manner that it is impossible to close the main switch of either motor while the controller is at the "on" position.

The general construction of these large induction motors is practically the same as that of the smaller ones built by the Allis-Chalmers Company. The stator punchings are supported in a substantial yoke to which the housings carrying the bearings are bolted. The bearings are adjustable, to permit compensation for wear and thus maintain a uniform air gap between stator and rotor. The stator is wound with copper strip with the slot insulation formed around it under pressure in steam-heated moulds. The end connections of the winding are rigidly supported, to prevent any distortion due to abnormally large current.

The rotor, Fig. 2, is mounted on a spider provided with cast-steel end rings between which the laminations are held. The rotor slots are of the partially closed type, and the rotor bars are securely held in place by the overhanging tips of the teeth. The bars are bolted at each end to the bronze short-circuiting rings, thus making a very strong rotor that can be safely run at high peripheral speed.

Electric Locomotives for the New York Central & Hudson River Railroad

LAST October the first half of the 50,000 mile-endurance run of the first high-speed electric locomotive No. 6000, built jointly by the General Electric Company and the American Locomotive Company, of Schenectady, N. Y., was completed on the test tracks of the New York Central lines in Schenectady. On June 12 this locomotive completed the second half of this exhaustive service test.

The maintenance expense per mile for the complete 50,000-mile run amounted to 0.0126. This figure includes all maintenance expense on

EIGHT ELECTRIC LOCOMOTIVES BUILT JOINTLY BY THE GENERAL ELECTRIC COMPANY AND THE AMERICAN LOCOMOTIVE COMPANY, OF SCHENECTADY, N. Y., FOR THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD

motors, brake shoes, tires, inspection, and other miscellaneous items. Moreover, the operating conditions were much more severe than those to which the thirty-five electric locomotives, which have been ordered, will be subjected. The test locomotive hauled a train averaging from 200 to 400 tons over a six-mile track, and high-speed running under these conditions involved higher braking and accelerating duty than in regular operating service.

The illustration on this page shows eight of the thirty-five 100-ton, 2200-H. P. electric locomotives built for the New York Central lines, following the same design as the locomotive which has made such a satisfactory record. There are, in all, fourteen machines now complete. Of the eight locomotives shown, Nos. 3401 and 3402 have been shipped to New York. The remaining locomotives are well under way at the shops of the General Electric Company and American Locomotive Works, and it is expected that the complete number, thirty-five, will be ready for service early in October.

Graphite Brushes

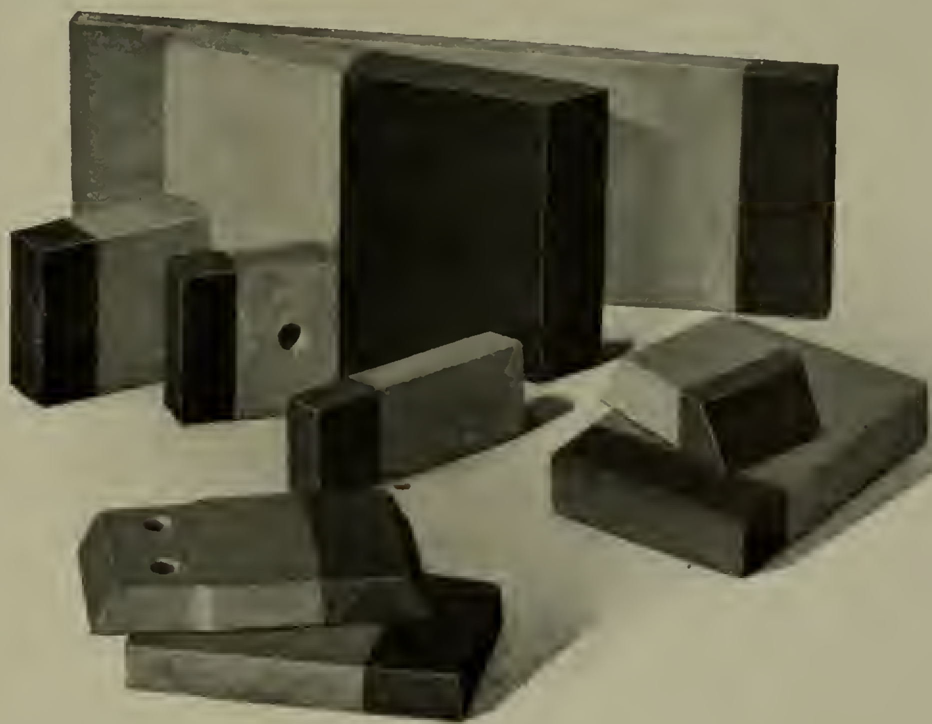
THE graphite brushes manufactured by the Joseph Dixon Crucible Company, of Jersey City, N. J., were first made by them for use in their own lighting and power plant in place of carbon brushes, with which they were having some trouble. Later, they improved upon these brushes, and are now selling them in the forms shown in the accompanying illustrations.

In comparison with carbon brushes, graphite brushes cause less friction with the commutator; they are soft, and automatically lubricate the commutator.

It is not claimed that the graphite brush is especially desirable for low voltages and high current density, for the graphite brush should have greater resistance and is best used in connection with high voltages. In view of its higher contact resistance, it should be used with a somewhat lower current density than a carbon brush.

Tests made by the company confirm the conclusion that pressures lower than three pounds per square inch must not be used with graphite brushes in any case. With pressures greater than six pounds per square inch, it was found that the commutator would be likely to blacken and the brushes wear rapidly.

Anyone can quickly and conveniently test the pressure he is using by means of an ordinary spring balance. All that is needed is to hook the balance on the brush holder and



GRAPHITE BRUSHES MANUFACTURED BY THE JOSEPH DIXON CRUCIBLE COMPANY, OF JERSEY CITY, N. J.

lift until the brush clears the commutator. If the hook of the scale cannot be caught on the brush holder, a piece of ordinary cord can be passed around and caught on the hook of the balance.

For the convenience of users of Dixon's graphite brushes the following summary is given of the conclusions deducted from tests and observations made by Prof. Albert F. Ganz, of Stevens Institute of Technology:—

SOME MORE DIXON GRAPHITE BRUSHES

Dixon's graphite brushes must not be used on the same commutator with carbon brushes.

Before Dixon's graphite brushes are applied to a machine the commutator must be given a true and polished surface. A rough commutator will quickly wear away graphite brushes.

No oil, vaseline or other lubricant must be used with Dixon's graphite brushes, but the commutator must be kept perfectly free and clean from such materials.

When a new graphite brush is inserted on a commutator, its surface should be fitted to the surface of the commutator by means of finest sand paper.

The brush holder should be so constructed that the entire contact surface of the brush is touching the commutator and that the brush pressure is evenly distributed over the contact surface of the brush.

The brush pressure should not be less than six pounds per square inch. For slow-speed machines with little vibration, the lower pressure will give satisfactory results, while for high-speed machines with considerable vibration, the high pressures must be used.

Where two or more brushes are used in parallel on one machine, it is important that the brush pressure be the same for all brushes.

Electric Railway Building in Oregon

An electric road for the transportation of freight as well as passengers is that of the Oregon Electric Railway Company, entering the Willamette Valley, south of Portland. This road opens up a very rich territory in the center of which is located Salem, the capital of Oregon.

The first section of the railroad will be fifty miles in length, and will connect the City of Portland with Salem. It will be constructed in accordance with the best railway practice, of 70-pound rails on rock-ballasted road-bed, with a maximum grade of 2.2 per cent. and a maximum curvature of 5 degrees. A portion of the 50-mile line will consist of a tangent 26 miles with practically no grade.

The road crosses the Willamette River, over which is being constructed a steel deck span bridge on concrete piers. There are five piers in the river, and the approaches to the bridges on either side consist of fills aggregating about a thousand feet in length. The bridge proper consists of four 200-foot spans, the distance from the rail to the surface of the river being 110 feet. This is one of the largest bridges in the State, and is being constructed for the heaviest type of electric locomotive drawing trains of 100,000-pound freight cars.

The road enters the south boundary of the City of Portland, and continues into the center of the city, where the passenger station is located. Connection will here be made by the Southern Pacific, Northern Pacific and Great Northern Railroads. The country through which the road passes is the garden spot of Oregon, and is extremely fertile, and owing to the climate, and the fact that there are no frosts or cold weather during winter time, is rapidly building up with farming and manufacturing population.

There will be a number of branches aggregating about 50 miles constructed as soon as the main line is in operation, and plans are in contemplation to extend the main line to the south of Salem to the City of Eugene, making an electric railway system of about 150 miles.

All the engineering and construction work is being done by W. S. Barstow & Company, engineers, of Portland, Oregon. Among the financial people interested in the enterprise are Moffat & White, bankers, of New York; Chas. Pratt & Company, of New York; the Franklin Trust Company, of Brooklyn, N. Y., and numerous other leading financiers of the East and West. This railroad is one of the first to be constructed for heavy traffic in the State of Oregon. The passenger express service will be of the best, the running time between Portland and Salem being one and one-half hours, against three hours with the present railroad service.

A New Electric Dump Car

The new electric slack dump car built by the Jeffrey Manufacturing Company, of Columbus, Ohio, and shown in the annexed illustrations, covers a wide range of usefulness, and is adapted to many requirements. The car consists of a structural steel truck upon which is mounted a steel hopper, and is provided with two Jeffrey 250-volt motors, one being geared through a single reduction to each axle, the gears being enclosed in dust-proof cases and running in oil.

The journal boxes are removable without dropping the wheels, and are provided with renewable steel wearing faces. The boxes are held in cast-steel pedestals, which are securely bolted to the steel channel frame, and which are also strengthened at the lower end by diagonal braces. Four sand boxes of liberal capacity are provided. The brake is of the well known Jeffrey self-locking type.

Heavy sheet steel, suitably braced and reinforced, is used in the construction of the copper, which, when loaded as shown in the illustration, has a capacity of 25,000 pounds of run-of-mine coal. This hopper is so supported on the frame that the weight is uniformly distributed throughout the structure.

Probably the most novel feature of this car is the ease and rapidity with which the load may be discharged. To facilitate this, the bottom of the car slopes from the hip or ridge in the center down to the bottom edge of each side door, and at the front end is a triangular face or slope descending from the ridge to the bottom edge of the front door. The angle of slope of the bottom is made whatever may be necessary to readily discharge the material to be hauled. The doors are securely hinged to the body of the hopper, and are so hung that they open slightly by their own weight whenever the holding chains are loosened.

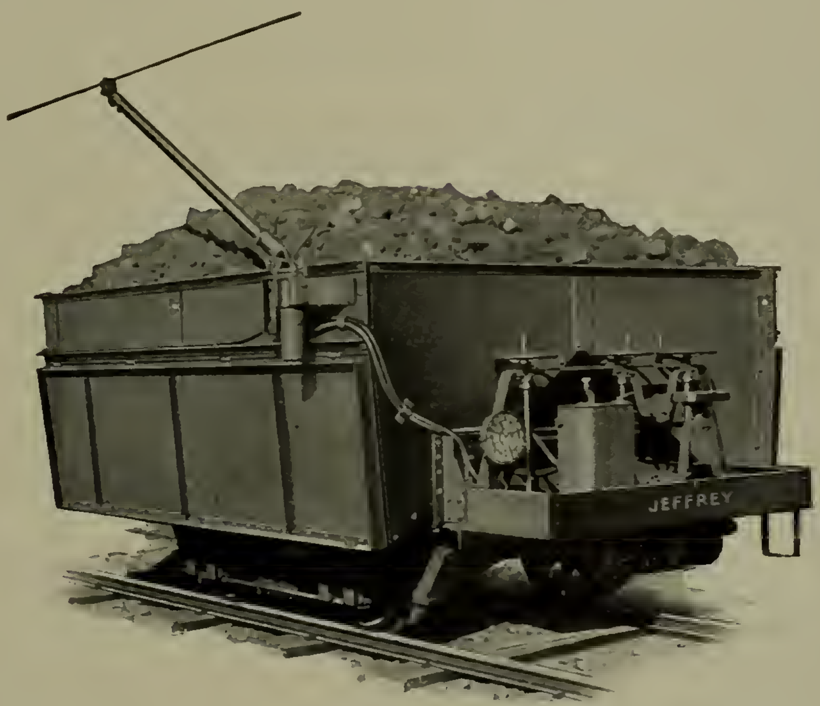


FIG. 1.—A NEW ELECTRIC DUMP CAR BUILT BY THE JEFFREY MANUFACTURING COMPANY, OF COLUMBUS, OHIO

FIG. 2.—ANOTHER VIEW OF THE JEFFREY ELECTRIC DUMP CAR, SHOWING SIDES OPEN

Each door is provided with three chains for holding it closed. The two side doors are operated simultaneously, the front door being operated independently. The chains are wound upon windlass shafts, and each chain is provided with length adjustment, so that the strain may be equally distributed on all of the chains. The method of operating these doors may be arranged to suit the purpose for which the car is to be used, for instance, each door may be operated separately, and two may be operated at the same time, or all the doors may be arranged to operate simultaneously.

The mechanism for operating the doors is self-locking in any position, and is easily and quickly manipulated. Fig. 1 shows the convenient arrangement of the operating mechanism. The vertical shafts and hand wheels at the right and left operate the front and side doors respectively, and the hand wheel and shaft in the center operate the brake. At the left of the operator's seat is the controller, and at the right, supported between the brake and the front door control shafts are the sand valve handles.

Each car is provided with two headlights, and a gong is located under the floor plate within reach of the operator's foot. The car is used for handling slack, and discharges its load from a trestle at a considerable height above the ground. Dumping the slack from the front and both sides will gradually form a fill or embankment upon which extensions to the track may be laid. These cars are built in several sizes.

The Generating Units in the New Public Service Building of the Milwaukee Electric Railway and Light Company

THE handsome new Public Service Building of the Milwaukee Electric Railway & Light Company, which was first thrown open to the public on the occasion of the convention of the American Institute of Electrical Engineers in Milwaukee, on June 1, is said to be the finest and best equipped of its kind in the country.

This building offers generous quarters for all departments of the operating organization, as well as affording an excellent terminal for the various interurban lines radiating from the city of Milwaukee. It is located near the centre of electrical distribution for the city, and a portion of the basement is used as a generating station. An especially interesting power plant is now being installed there.

The three generating units for this plant consist of non-condensing turbines of the Parsons type, built by the Allis-Chalmers Company, of Milwaukee, Wis., each driving a 1500-kilowatt, 60-cycle, 2300 to 4000-volt Allis-Chalmers alternating-current generator. The turbines are not of the standard design, but were specially built to be run non-condensing. These turbines have a guaranteed steam consumption per kilowatt-hour of 44 pounds at three-quarters load, 40 pounds at full load, and 41 pounds at one-quarter overload, with an absolute back pressure of 22 pounds.

The turbine equipment is designed to be run only when steam is needed for the heating system, and the current output of the turbine-driven generators will be fed into a lighting network. An exhaust trunk for the three units is provided with a vertical atmospheric pipe built in one of the partition walls. The exhaust trunk is directly connected with the district heating system through two 24-inch underground steam mains.

In order to make this installation more flexible and permit of equalizing the load between the direct-current and the alternating-current distribution systems, two Allis-Chalmers motor-generator sets will be installed close to the turbine units. Each of these motor-generators will consist of a 1500-kilowatt motor, with the same characteristics as the turbine generators, mounted on the same shaft with a 300-volt, direct-current generator. The installation of this motor-generator equipment was made necessary because at the time the machinery was ordered it was not commercially possible to purchase a 1500-kilowatt, direct-current turbine unit, and reciprocating engine units could not be used because of the continual jar which they would give to the building above them.

The alternating-current generators are designed with an enclosed armature casting, so that the usual humming during operation will be greatly lessened. Each generator is wound with four-wire, three-phase circuits with 2300 volts difference of potential between any leg and the neutral.

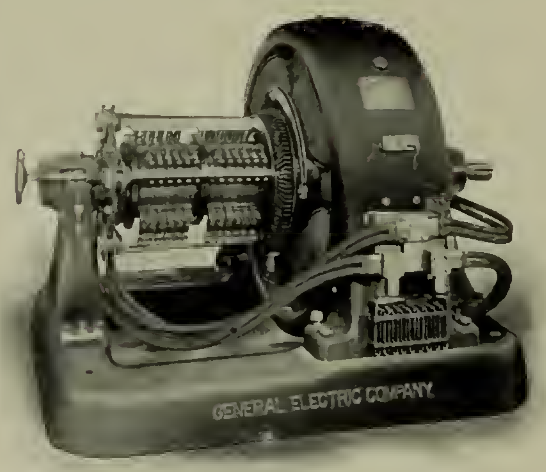
As part of the auxiliary service, a continuous supply of compressed air is furnished by two motor-driven Christensen air compressors, each of 150 cubic feet capacity, now manufactured by the Allis-Chalmers Company. A large part of the output of these compressors is used for operating the pneumatic tube service which connects the various departments. A portion of the compressed air is used in the heat regulating service which controls, by means of thermostats, each steam radiator in the building. The compressed air is also used at about 80 pounds pressure for the blast forges in the machine and repair shops.

Motors for Testing Purposes

SEVERAL especially interesting motors have recently been installed for testing purposes by the International Steam Pump Company in its new Worthington Hydraulic Works at Harrison, N. J. The motors were built by the General Electric Company, of Schenectady, N. Y., and are used in testing blowers, pumps and air compressors, being permanently installed on suitable foundations, so that the machinery to be tested can be easily brought up to them. The machines are remarkable because of their high overload capacity and wide speed range for these purposes.

The largest of these units is shown in the accompanying illustration. This motor delivers 200 H. P. at 220 volts, running at 750 to 1500 revolutions per minute and 100 H. P. at 110 volts, running at 375 to 750 revolutions per minute. A similar range in capacity and speed is obtainable with each of the other motors, which have full load ratings of 100 H. P., 30 H. P. and 10 H. P., respectively, at 220 volts.

All the machines are of the four-pole type and will carry 50 per cent. overload for two hours at any speed within the range specified. The



A MOTOR BUILT BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y., FOR TESTING PURPOSES AT THE WORTHINGTON HYDRAULIC WORKS, HARRISON, N. J.

motors operate on the three-wire system, the fields being excited from the 220-volt mains, and the armatures being connected through double-throw switches to the 220-volt or 110-volt mains, according to the speed range required. The speed ranges are obtained by field control, and the 200 H. P. and 100 H. P. machines are built with commutating poles.

A German silver resistance, shown just below the terminal board in the illustration, is used to make the final adjustment of the current in the commutating field coils. By this arrangement absolutely sparkless commutation at all loads, including 50 per cent. overload, is assured.

Aside from the large capacity and high-speed range, these motors have several interesting structural features. On account of the high surface speed of the commutators in the 200 H. P. and 100 H. P. machines, an improved shrink-ring type of commutator is used. The brush rigging is similar to the form recently adopted in high-speed, D. C. Curtis turbine-generators. The brush holder studs are of stiff, ribbed design, and the brush holders are secured to the studs by bolts passing through machined joints of special form, making the entire brush system extremely rigid in spite of the unusual length of the studs.

The motors are materially lightened by making the magnet frames of steel, and both armature and field coils are built to give proper ventilation at the overload capacity. Particular attention has been paid to balancing rotating parts so that vibration within the wide variation of speed and load is eliminated.

There is a wide field among machinery manufacturers for motors of this type having high overload capacity with high speed range, not only for permanent installation for general testing work, as in the case of the machines for the Worthington Works, but also for the driving of machine tools.

Universal Insulator Supports

INSULATOR supports manufactured by the Steel City Electric Company, of Pittsburg, are shown in the annexed illustrations.

The supports are principally used for attaching standard forms of insulators to the frame work of steel buildings, especially mills, factories, machine shops, foundries and buildings of similar character, where the structural steel work is exposed and where the "open" style of wiring is used. They are also largely used for securing in place pipe, chairs and hangers, motor starters, cut-outs, junction boxes, switches and the like.

AN INSULATOR ON ONE OF THE UNIVERSAL INSULATOR SUPPORTS MANUFACTURED BY THE STEEL CITY ELECTRIC COMPANY, OF PITTSBURG

For special work they are drilled and tapped as ordered.

The insulator supports being of metal, the use of all inflammable construction material, such as wood timbers, is avoided. The loosening of bolts and twisting of timbers, due to shrinkage of such wooden pieces, is also entirely avoided and the steel structure is not weakened by drilling holes for supporting insulators

UNIVERSAL INSULATOR SUPPORTS ATTACHED TO AN ANGLE IRON

or timbers, as no holes are needed for this device.

They are universal in application and can be used anywhere, without restriction as to location. They are designed to attach to any form of standard rolled section from the heaviest 24-inch I-beam to the smallest angle or T in common use. They can also be attached to round or square rods, gas or other pipes, flat bars, plates, the edges of tanks, braces, guy rods, etc., in fact, to anything over which the clamp jaw will go. This is also an important consideration when changes in previous work are made. There is no special

A UNIVERSAL INSULATOR SUPPORT WITH TWO INSULATORS

work to throw into the scrap, as in the case with special forgings, hook bolts, and the multitude of similar affairs familiar to every construction man who has had to do with this kind of work. If the work is to be changed, as for instance temporary work, it is only necessary to change the location of the supports, and, if the work is taken out, to put the supports into stock.

The most important part of the labour cost in open work goes into preparing the runs to receive the wires, viz.: laying out the most available locations for the hangers, blocking, etc., making measurements and sketches of all structural features and designing and sketching the necessary special work according to the number of wires, their size, direction of strains, and other local considerations, getting carpenters, blacksmiths, machine shops, hardware dealers, and others, to prepare special work and materials, with the annoying delays so often thereby attendant, and collecting and assorting these various devices and materials each to their assigned special places.

By the use of the universal insulator supports all of this costly preparatory work is avoided. The work will fit in place no matter where the wires go, and it is only necessary to provide the proper number and size of insulator supports to correspond to the desired number of insulators according to the route previously laid out.

Personal

E. N. Chilson has been appointed purchasing agent of J. G. White & Company, of New York. E. V. Peters will continue to act as assistant purchasing agent as heretofore.

At an election of officers of the Newton Machine Tool Works, Inc., of Philadelphia, made necessary by the death of Charles C. Newton, founder and president of the company, the following were elected:—Harry W. Champion, president; William M. Graham, treasurer; Ellis J. Hannum, secretary. These gentlemen were closely associated in executive positions with Mr. Newton for many years. No change in the conduction of the business will be made.

W. S. Barstow, of W. S. Barstow & Co., Inc., of New York, has just returned from Portland, Ore., after a four weeks' trip. He reports that there is in contemplation the building of several miles of railroad extensions in connection with the Oregon Electric Railway Company, for whom W. S. Barstow & Co. are now building and equipping about sixty miles of road. It is expected that part of the main line between Portland and Salem will be in operation September 1, and that cars will be operated between the two cities by July 1, 1907.

W. F. Hessel, of Chicago, has just assumed the position of general sales manager of the Stuart Howland Company, of Boston, Mass. This is a valuable addition to the rapidly increasing organization of the company, as Mr. Hessel has been associated with some of the largest companies of the country, has a broad acquaintance, and has had a wide experience in the electrical field. His early experience in the practical operation of central stations has proved particularly useful in the electrical supply business, with which he has been identified for the past ten years. During the last four years Mr. Hessel has successively occupied the positions of sales manager for the Western Electric Company, manager of the Standard Electric Company, of Cincinnati, Ohio, which is the Ohio branch of the Western Electric Company, and Western sales manager of Pass & Seymour, Inc. Prior to that time, he was associated with the Eastern interests, and had many Eastern friends, who will be pleased to learn that he has returned to again take a place among them.

George L. Rockwood was recently appointed to the professorship of steam engineering in the Worcester Polytechnic Institute. Mr. Rockwood is a graduate of the Worcester Polytechnic Institute in the class of 1888, and is one of the leading authorities in this country on steam engineering.

Daniel D. Banks, who as chief engineer had charge of all the track and other construction work of the United Railways & Electric Company, of Baltimore, has resigned to take up independent consulting work. It is said that the company will not name successors, with like authority, to Mr. Banks and to P. C. Keilholtz, who resigned lately as consulting engineer. Part of their duties will be filled by the staff of L. B. Stillwell, of New York. At the present time Mr. Stillwell's electrical assistants are making an examination of the Pratt street power station.

J. W. Lieb, Jr., assistant general manager of the New York Edison Company, recently returned with Mrs. Lieb from an extended European trip. Mr. Lieb received many marks of honour while in Italy, and also enjoyed the hospitality of the British Institution of Electrical Engineers while in England.

Obituary

H. P. Bruce, formerly general manager of the Demerara Electric Company, of British Guiana, associate engineer of the Pittsburg Railways, and latterly connected with the firm of Rockwell & Bruce, of New York, died suddenly on July 26. He entered the electrical field in the early days of the Thomson-Houston Company, his activities since then being in connection with some of the largest work in the East. He leaves a widow and one child.

Trade News

W. S. Barstow & Co., of New York, have been engaged as engineers for remodelling the plant of the Jamestown Worsted Mills, at Jamestown, N. Y. Plans will be drawn covering an extensive addition to the power plant, and the plant will be changed over to an electric motor drive throughout. Barstow & Co. recently completed a similar installation for the Hartford Carpet Corporation, at Thompsonville, Conn. They have also been engaged as the engineers for the New Jersey Company, of Matawan, N. J., who are making improvements and additions to their plant. The remodelled plant will have double the capacity of the old one. In order to meet the increased shipping requirements, a large dock will be built on Matawan creek, and a new power house will provide for electric drive and lighting throughout the plant.

The Carnegie Steel Company has purchased for its Homestead works two 2000-KW., alternating-current generators driven by gas engines. These units are to be furnished by the Allis-Chalmers Company, of Milwaukee, and they complete an order recently given for machinery costing approximately one million dollars to be built by the Allis-Chalmers Company for the Homestead plant. It includes three gas-engine-driven electric units and four gas blowing engines, the aggregate capacity of these machines being nearly 30,000 H. P. This follows close upon the recent million-dollar order given to the Allis-Chalmers Company by the Indiana Steel Company for the electrical equipment of its new plant at Gary, Ind., where gas engines of the same type and capacities, operating on waste gas from the blast furnaces, are to serve as prime movers for electric generators supplying current to the steel mills. Other purchases of gas blowing engines and gas-engine-driven electrical units from the Allis-Chalmers Company amount to practically a million dollars more, so that sales during the past few months have aggregated three million dollars. Now another notable sale of gas-engine-driven generating units has just been made to the Milwaukee Northern (electric) Railway Company, whose plant will represent the largest installation of this kind on the continent. The power house of this company, which will be situated at Port Washington, Wis., is to contain three horizontal, twin-tandem gas engines, each having a rated capacity of 1500 H. P., with liberal allowance for overload, direct connected to three 1000-KW., three-phase, 25-cycle, alternating-current generators. The complete units will be built and installed by the Allis-Chalmers Company. The exciting units for these generators, which are to be driven by special vertical gas engines, will also be furnished by the Allis-Chalmers Company. All of the engines are to operate on producer gas.

As announced in a previous issue, the Crocker-Wheeler Company have now completed arrangements and have opened an office and warehouse at 208 First street, near Howard, San Francisco, Cal., with H. C. Baker as local manager. They have also opened an office at 447 Pacific Electric Building, Los Angeles, Cal., with L. Cummins as representative, and are arranging to establish an office in Seattle, Wash., in the near future.

The Bay State Lamp Company, of Danvers, Mass., has started up again after its annual summer shut-down. The increasing business of the company made necessary a considerable addition, which has just been completed. During the vacation also, a number of alterations and improvements in the factory were made for the purpose of the better handling of the fall and winter business.

The Gas & Electric Development Company, of Philadelphia, reports the sale of the plants of the Frostburg Gas & Electric Company, of Frostburg, Md., to Philadelphia interests.

The Ball Engine Company, of Erie, Pa., report a very brisk demand for their Corliss four-valve type of engine. Among recent orders are the following:—One 700-H. P. cross-compound for the city of Aurora, Ill.; one 800-H. P. cross-compound for the National Tube Company, Pittsburg, Pa.; two 700-H. P. cross-compound for the Duluth & Iron Range Railway, Duluth, Minn.; one 600-H. P. cross-compound for the Flint Light & Power Company, Flint, Mich.; one 700-H. P. cross-compound for the Pennsylvania Railroad Company, Altoona, Pa.; one 550-H. P. single-cylinder for the Washington Electric Light & Power Company, Washington, Pa.; one 550-H. P. single-cylinder for the Natalbany Lumber Company, Montpelier, La.; one 400-H. P. single-cylinder and one 320-H. P. single-cylinder for the Craddock-Terry Company, Lynchburg, Va.

One of the few American exhibits at the exposition, at Milan, Italy, now open for the season of 1906, is that of the "Long Arm" system of electrically operated bulkhead doors. The exhibit consists of a horizontal sliding door, a vertical sliding door, a hatch gear and the electrical emergency station from which, aboard ship, all important bulkhead doors and the armour hatches are operated. The types of doors and the hatch forming this exhibit are all of the latest model. A great deal of interest has been manifested in Italy in the "Long Arm" system, which is in use on all the new warships of the United States Navy, and it is doubtless somewhat due to the educating influence of this exhibit, that a movement has been started in Italy to have incorporated in the governmental regulations for passenger ships a clause making the installation of power doors obligatory.

New Catalogues

An order guide for supplies and car and truck specialties was recently sent out jointly by the J. G. Brill Company, of Philadelphia; the G. C. Kuhlman Car Company, of Cleveland; the American Car Company, of St. Louis, and the John Stephenson Company, of Elizabeth. The names of the various items are given, with a number annexed corresponding to a number on the illustrations, so that the correct name of the part needed may be known.

Iron and steel works equipment built by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, are dealt with in a pamphlet recently issued. Open-hearth steel melting furnaces of both stationary and rolling type are first taken up, reheating furnaces and equipment then being dealt with. The Foster patent water-sealed reversing valve for regenerative gas furnaces, open-hearth furnaces, heating furnaces, soaking pits, crucible furnaces, glass furnaces, and the like, are also illustrated and described.

Steel tanks built by the Oswego Boiler & Engine Company, of Oswego, N. Y., are illustrated and described in a recent catalogue. The tanks listed vary in size from 18 inches in diameter with 3-16-inch shell. Coil tanks, with iron or brass coils, are also listed. The company also turn out boilers of every description, smokestacks, steel chimneys, breechings, boiler castings, standpipes, carburettors, vulcanizers, and digesters, and are prepared to construct general iron work and build special machinery to any design and specification.

Lightning protective apparatus is dealt with in a new pamphlet sent out by the Westinghouse Electric & Manufacturing Company, of Pittsburg. It has upon the cover a very interesting illustration of a lightning stroke from cloud to ground. The general consideration, performance, and selection of protective apparatus are discussed, and the various types of Westinghouse arresters are illustrated and described.

The James Leffel & Co., of Springfield, Ohio, have issued an attractive new 52-page catalogue, illustrating and describing steam engines and boilers. The details of construction are plainly shown and fully explained, and the catalogue will be of interest to any prospective purchaser of steam power equipment. A copy will be furnished free to prospective buyers stating their wants, and addressing the company as above for catalogue "O."

A new folder sent out by the H. T. Paiste Company, of Philadelphia, is devoted to plug cut-outs, panel cut-outs for rotary snap switches, tablets, and attachment plugs.

A book on cables, sent out recently by the Standard Underground Cable Company, of Pittsburg, should prove of value to any one interested. Besides telling all about the company's products, it gives a variety of useful tables and information about cables too great to be listed here. With three grades of binding the book is sold for $.50, $.75, and $1.00.

The Machine Tool Pocket List, formerly published by the Angus Ballard Company, has been purchased by the Geo. H. Gibson Company, advertising engineers, of New York City. The size of the book will be increased from 3½ inches by 6 inches to 4 inches by 9 inches, a larger pocket or pigeon-hole size, and the buyers' finding list of machine tools and supplies will be made still more complete and definite, if possible, although the present list covers over a thousand firms and about two thousand articles and types of tools used in machine shops. Brief articles of interest to manufacturers of machinery will also be added, and the list will be combined with "Manufacturing," a journal in which the Geo. H. Gibson Company describes and lists important patents and other industrial opportunities.

A booklet telling about carbon brushes was recently issued by the Speer Carbon Company, of St. Mary's, Pa. The advantages of Speer brushes are discussed and curves are given showing the results of heat, brush friction, voltage drops, brush tension, contact resistance, and wattage loss tests.

A folder recently sent out by the Wagner Electric Manufacturing Company, of St. Louis, Mo., deals with transformers. Those illustrated vary in capacity from 1 to 500 KW. They are of the air-cooled type, the ail-filled, self-cooled type and the dry type.

Gas and gasoline engines built by the Bruce-Meriam-Abbott Company, of Cleveland, Ohio, are illustrated and described in a catalogue recently issued. The engines are shown in detail and the various features are fully described. The engravings are excellent, and the pamphlet as a whole is a creditable piece of work.

Industrial railways built by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y., are illustrated and described in a catalogue recently issued. The various features of this well-known system are discussed and numerous illustrations show the wide variety of cars built for industrial use.

Motors and generators, varying in size from 1 to 35 H. P., are dealt with in a bulletin recently sent out by the Allis-Chalmers Company, of Milwaukee, Wis. Another bulletin sent out by the company deals with heavy-duty engines of the belted-type. Many of the details are illustrated and described, and a table gives the indicated horse-power for various cut-offs of each size.

Water-wheel governors are illustrated and described in a catalogue recently issued by the Sturgess Engineering Department of the Ludlow Valve Manufacturing Company, of Troy, N. Y. The several types of governors are dealt with and a number of illustrations show some of the water-power plants regulated by Sturgess governors.

Magneto switchboards built by the Automatic Electric Company, of Chicago, are illustrated and described in a catalogue recently issued. Express type and bell type switchboards are dealt with and the details are illustrated and described. The pamphlet is attractively gotten up and should prove of value to anyone interested in this subject.

The "Gem" wire grip, manufactured by the Colman J. Mullin Company, of Brooklyn, is illustrated and described in a folder recently issued. The grip consists of a cylindrical wire network, which tightens on the cable as it draws at one end.

Marsh boiler-feed pumps built by the American Steam Pump Company, of Battle Creek, Mich., are dealt with in a recent catalogue. The various types are illustrated and described, tables of dimensions and capacity being also given. Another pamphlet deals with deep-well engines and pump cylinders.

"The Economical Lighting of Industrial Plants" is the title of an attractive booklet recently issued by the Cooper Hewitt Lamp Company, of Pittsburg. The illustrations show installations of the Cooper Hewitt lamps for various classes of service, including warehouses, erecting shops, manufactories and offices.

A pamphlet recently issued by the Nernst Lamp Company, of Pittsburg, treats of the Nernst series alternating vertical-glower street-lighting system. The details of the system are described with illustrations showing the regulating apparatus and transformers.

A new catalogue sent out by the Atlas Engine Works, of Indianapolis, Ind., is devoted to throttling and automatic single-valve engines. The advantages of each type are discussed, indicator cards also being given. The various details are illustrated and described, and tables give the main dimensions and indicated horse-power and various speeds.

A new series of bulletins sent out by the Chandler & Taylor Company, of Indianapolis, Ind., are devoted to inclosed direct-connected engines, high-speed automatic cut-off engines, high-speed throttling engines, stationary tubular boilers, medium-speed throttling engines, medium-speed double throttling engines, portable fire-box boilers, plain vertical boilers, and semi-portable outfits.

Of the 923 coal-cutting machines in use in the United Kingdom, 355 are electrically driven, and 555 are operated by compressed air. This is a total increase for 1905 of 155 machines, 85 of which are electrically driven and 70 driven by compressed air.

Wireless Telegraphy at the Isles of Shoals

By H. S. KNOWLTON

An interesting wireless telegraph station is in operation this summer at the Isles of Shoals, a group of seven islands lying 10 miles out in the Atlantic Ocean, off the Maine and the New Hampshire coasts. The installation was first placed in operation in the summer of 1905, and it is located on the island of Appledore, close by the landing of the steamboat line which connects the shoals with the city of Portsmouth, N. H. The installation is equipped with the apparatus of the Stone system, and its object is to furnish telegraph service between the islands and the nearest mainland wireless telegraph station, which is located at the Portsmouth Navy Yard.

The Appledore station is maintained by the Stone Telegraph & Telephone Company, of Boston, a certain minimum of business being guaranteed by the syndicate which controls the Appledore and Oceanic hotels on Appledore and Star islands, respectively. The traffic originates largely among the guests of the hotels, as all the telegraphic business of the islands is conducted through this station.

The Portsmouth Navy Yard station is about 10 miles distant, and the tariff between the Appledore and the Portsmouth stations is 25 cents for 10 words. When a message from the islands is received at Portsmouth it is turned over to the Postal Telegraph-Cable Company or the Western Union Telegraph Company, according as the sender specifies. The charge from Portsmouth to the destination of the message is added at regular telegraph or cable rates. Messages coming to the Isles of Shoals from other points bear a similar additional charge in the opposite direction.

Aside from the business occasioned through the guests of the hotels, a considerable amount of ordering supplies by wireless from Boston through Portsmouth is done by the hotels themselves. Personal messages, important stock market transactions, weather reports and other kinds of business are handled, the office being open from 8 A. M. to 8 P. M. on week days, and from 9 to 10 A. M. and 5 to 6 P. M. on Sundays. At the recent convention of the American Unitarian Association, held at the Isles of Shoals, the proceedings were reported by wireless telegraphy to "The Boston Herald." As many as 18 outward messages a day have been sent from Appledore. Although there are three steamboat railways daily to the mainland, there seems to be a real demand for the wireless installation.

The Appledore station is not designed for long-distance transmission, and it is therefore equipped with low-powered apparatus. The mast which supports the aerial wires is about 30 feet high and carries 20 rubber-insulated No. 12 copper wires suspended from glass insulators attached to a horizontal yard arm. These wires are dead-ended at the top of the mast and are brought together at the bottom in a cable which enters the station cabin through a porcelain bushing. The cable is here connected with the transmitting and receiving apparatus.

Battery power is used in this station, about 12 volts on the induction coil primary being sufficient to communicate with Portsmouth. About 500 feet of wire are used in the antennæ. Ordinarily from 6 to 8 cells of storage battery are employed in the transmitting circuits. The cells are of the "Chloride" 7-plate type, and are charged about every ten days in Portsmouth, a spare set being kept on hand as a reserve. The charging rate is 7.5 amperes on a 10-hour basis.

The wave length of 320 meters used by the United States Navy Department is also used in the Isles of Shoals apparatus, and the inside of all the instrument boxes are lined with tin, which is grounded. About 50,000 volts are used on the secondary side of the transmitting circuit. The standard Stone electrolytic receiver with telephones is employed, and on account of the low height of the mast the weather has very little effect on the efficiency of the transmission. Even in thunderstorms, it is not necessary to shut down the equipment. Although the sending power of the station is purposely limited, messages have been picked up from considerable distances. At the time the North Atlantic Squadron was going through evolutions off Rockport recently, the wireless dispatches between the various battleships and between the fleet and the shore were read at Appledore, as are messages from other ships passing along the coast. Cape Elizabeth, Me., and Cape Cod, Mass., are frequently heard from by Appledore. The entire equipment, exclusive of the mast and antennæ, is installed in a cabin about 6 feet long by 8 feet wide.

At the Portsmouth Navy Yard, a high-powered station is in continuous day and night service under the control of the government. This is one of the busiest stations on the Atlantic Coast, and three operators are required to handle the business, whereas one operator takes care of the little station on the Isles of Shoals. At the Portsmouth station, the apparatus is also that of the Stone system, the mast being 180 feet high and strongly guyed to hold it securely in place upon a concrete and ledge foundation in heavy gales and storms.

Messages have been received at Portsmouth from the steamship "Savannah" at a distance of 1380 miles, and under favorable conditions the station has communicated with Beaufort, N. C. Messages were received from the floating drydock Dewey for some time after she started on her Eastern trip.

Power for the operation of the Portsmouth station is drawn from a generating plant in the Yard, located about half a mile from the wireless cabin. Current is taken at 110 volts direct, and transformed to 110 volts alternating current, 60 cycles, by a 5-KW. Holtzer-Cabot motor-generator set mounted in a small building just outside the main station. The alternating current is passed through the primary of a step-up transformer upon the depression of the sending key, and by means of a five-point multiple spark gap in the secondary circuit, an oscillating potential of about 50,000 volts is impressed upon the aerial wires, which in this case represent a total length of about 2000 feet of No. 8 copper, rubber insulated.

An indicating kilo-wattmeter is inserted in the primary circuit, and the power used in transmitting averages about 2 KW. The normal speed of the motor-generator set is 1800 revolutions per minute, but by means of a rheostat in the motor field, a speed of 2200 revolutions per minute can be obtained if desired. The motor-generator is protected by a special lightning arrester and spark gap shunt, with condensers. The step-up transformer is also carefully protected against excessive potentials.

The receiving circuits provide for a wide range of adjustment. Both inductance and capacity may be altered to suit the wave length in force and by means of a special "weeding-out" coil or tertiary transformer, the apparatus can be held sensitive to within 5 per cent. of the adjusted wave length. It is possible to communicate with the Isles of Shoals without difficulty, even though a large number of wireless messages may be in process of transmission from other points, provided the wave lengths are suitably different.

About 12 amperes are ordinarily used in the primary circuit. The receiving circuit operates very satisfactorily on about 4 volts potential, which is obtained by two storage cells. These are charged from the 110-volt direct-current supply about once in two weeks. The condensers in the primary and secondary receiving circuits are of the sliding adjustable type. Make-and-break contacts are protected by fixed condensers. Ground connections are made by the wire netting known to the trade as "hen cooping," being set into the ground over a wide area around the signal house.

An important feature of this system is an arrangement whereby the sender of a message can be interrupted in case the recipient misunderstands him. When the sending operator depresses his key he short-circuits the primary receiving circuit, rendering it immune from electrical disturbances, and also opens the receiving circuit, protecting it from violent oscillations at the station while the spark is passing. On releasing the key the spark is stopped, the short-circuit removed, and the receiving circuit completed so that the sending operator will hear any signal which is sent in by the opposing operator between the dots and dashes which he makes on the transmitting key. In this way a great deal of time is saved through the avoidance of needless repetitions.

Time signals are sent out at noon daily by a solenoid magnet attached to the sending key, the magnet being actuated by an ordinary telegraph relay circuit. Both the Postal and the Western Union companies have wires to the Portsmouth station, which can communicate directly with Boston by land lines if desired.

Best Methods of Increasing Business

HOW TO GET IT, AND HOW TO KEEP IT

By W. C. ANDERSON, of Canton, Ohio

A Paper Read at the Recent Convention of the Ohio Electric Light Association.

THE electric light and power company is a manufacturer, selling direct to the consumer. There must be combined in the management both manufacturing and selling ability. The product is prominently before the public, but is little understood by them. It has inherent superiority that manifests itself to every user. The electric light gives off no odor, dirt or fumes; requires no attention; takes no notice of drafts, and can be controlled from any distance. It can be accurately measured and kept continuously in service. The principal form in which it comes, the incandescent lamp, is not efficient, however, in comparison with the Welsbach mantel. Had not this mantel been invented, the incandescent lamp would be today in universal use, by reason of economy as well as general desirability. Notwithtanding the greater cheapness of light from Welsbach mantels, the incandescent lamp has grown in use enormously, but in new and different fields from before the advent of the mantel.

In window-lighting, sign-lighting, theatre-lighting, and all kinds of decorative and display lighting, the incandescent lamp is without a competitor. For general space lighting, the direct current arc lamp and the alternating current Nernst lamp can compete with any other light with every opportunity of success.

The product of the central station is highly perishable; in fact, must be used the instant of production. Neither can it be transported any considerable distance, but must be consumed at or near the point of production. The market is, therefore, limited, and every possible customer can be card-indexed as to possible consumption with considerable accuracy. We must not make the mistake of underestimating our selling possibilities, but go after all possible customers with enthusiasm.

Nearly every private house is a possible customer, as nowhere else are the advantages of electricity so pronounced. We should expect to light every store and furnish both light and power to all the small factories. It is hardly to be expected that we can fully realize our expectations in this regard, but an attempt should be made in every case.

Elaborate and expensive business getting systems are out of the question in the smaller places, comprising the bulk of our membership, but the manager can have lists prepared of every class of possible customers, and call their attention by letter at intervals to his product. Newspaper advertising can also be used to advantage. Personal solicitation must be relied upon to do the actual work of business getting, but the assistance of the letters and advertising will be felt.

Good service is the principal factor in getting and retaining business. Good service consists of furnishing a continuous supply of electricity at uniform voltage to the premises of every customer, together with such supervision of each customer's installation as will result in his greatest satisfaction. In every case care should be taken to give the consumer the most useful light possible for his money. If a 16 candle-power lamp, with a prismatic glass reflector, will give the customer more useful light than a 32 candle-power lamp without a shade, the customer should be advised to that effect.

The central station manager must not only obtain the order for lighting but fill it in such a manner that the customer will feel that he is getting his money's worth, and repeat his order from month to month indefinitely. One well lighted store is the best canvasser for the neighbouring stores, and too great pains cannot be taken to give the store lighted the most handsome effect.

When a residence is wired, see that the stable is wired also, and that the lamps are of such candle-power as will give the best results without waste. Prompt and courteous attention should be given to all complaints and causes therefore remedied promptly.

A recording voltmeter should be in continuous service at every plant, and a chart should be taken at the end of each main at intervals, to see that the proper voltage is being obtained. Every plant that does not keep a switchboard attendant on that work, exclusively, should have an automatic voltage regulator, as nothing causes dissatisfaction so readily as to have the lights bright at one period and dim during another.

Like any other manufacturer, the central station manager must have a good factory to be successful. His machinery must not be antiquated nor insufficient. He cannot afford to waste his raw material in inefficient engines, boilers or electrical apparatus. His apparatus must be dependable and adapted to the supply of both light and power. No selling department can be successful without a good product to sell.

Electric lights are the street lights par excellence, and every city in the State should be lighted by a privately owned electric light plant. The public lighting done at a small profit, will give pole lines covering the entire city, so that private lighting and power customers can be obtained, where otherwise it would not pay to build pole lines to them for their use alone.

Every electric light manager recognizes the difference between supplying electric current to motors and in supplying the current to lamps. It is not the lamp renewal expense that governs the difference in cost, for lamp renewal cost is small. It means that a uniform rate cannot be successfully applied to our business. We must classify our business and charge according to our investment cost and operating expenses. All such methods of charging must be worked out so as to show a fair return and be equitable between different consumers. Large consumers must have special rates or isolated plants will result. There is no excuse for the existence of small isolated plants, as the central station will have a lower first cost for the necessary capacity as well as a lower operating cost. The cost of operating the isolated plant plus the interest on its capacity cost should allow the central station a fair profit on this class of business beside reducing the expense per unit of its own production.

Then the residence lighting is in another class. This should be on a two-rate basis, the demand being computed as a certain percentage of the lamps wired. Maximum demand meters are too expensive in first cost and care required to meet the needs of the case. By using a percentage of the lights wired with a minimum number on which to rate any house we will meet the average condition closely enough without any extra investment cost and with barely any extra bookkeeping.

The two-rate system of charging, such as is in general use will meet all the remaining classes of customers except small motor customers and those burning very long hours. For both of these classes of customers flat rates may have to be resorted to, especially in small cities where all the business in the town must be done from one central station in order to give load enough to insure a low operating cost. This must be done with extreme care, a flat rate per unit of demand being charged, computed on the investment cost and operating cost for the annual hours used. I believe this is less apt to cause trouble than a meter rate low enough to hold the business. Too much care cannot be taken in classifying business to make all rates bear justly against each class, the test of any special rate being whether it could be justified before a state lighting commission in case we had one in this state.

Every central station problem is complicated by past history and its particular environment and methods which may have been extremely successful under certain conditions elsewhere must be looked over carefully before being attempted.

In my judgment, the best help to success is to visit the plant of a successful manager. First see what he has accomplished and then try to duplicate his work or excel him.

Wireless Telegraph Conference

ON August 4, Brigadier-General James Allen, chief of the Signal Corps of the United States Army, sailed for Europe, where he will investigate the signal service in various foreign armies preparatory to attending the international conference on wireless telegraphy which will convene at Berlin on October 3. Charlemagne Tower, American Ambassador to Germany, will represent the State Department at that conference; Rear-Admiral H. N. Manney, United States Navy, retired, will represent the Navy; Gen. Allen will be the Army's representative, and John I. Waterbury, of New York, who is now in Europe, will represent the Department of Commerce and Labour.

Nearly every great Power will be represented at the Berlin conference, which will take up the work of international regulation of wireless telegraphy where it was left by the preliminary international conference held in Berlin in 1903. Germany, Austria, Spain, the United States, France, Hungary, and Russia were signatory to preliminary agreements then framed as the basis for an international convention regulating wireless telegraphy. Since then most of the other nations of importance have signified their intention to participate in such a convention.

According to United States Consul-General Guenther, at Frankfort, Germany, Russia has the longest telegraph lines of the European States, with a total of 109,375 miles. Next in order are France, 93,750 miles, and Germany, 83,750. Great Britain has 49,375 miles of lines.

The Telephone and the Telegraph in the Russo-Japanese War

IN the "Journal of the United States Artillery," Captain Wm. Lassiter gives a translation of an article by Colonel Neznamov on the teachings of the Russo-Japanese war. Among other things, the parts played by the telephone and the telegraph are briefly outlined.

The telephone, says the author, has rendered enormous service in battles of position, and has functioned perfectly. The instruction of telephone operators has offered not the least difficulty either in the infantry or in the artillery.

Experience has shown that the telephone should form part of the equipment furnished to the staff, to regiments, to batteries, and the like, at the rate of three or four stations and 10 versts (6.6 miles) of light cable per regiment or division headquarters, three or four stations and 6 versts (3.9 miles) of wire per battallion or isolated battery of artillery.

The equipment of the "telephone company" (85 versts, or 56.3 miles, of line) ought to remain exclusively at the disposition of corps headquarters, and suffices for its needs.

In the Russo-Japanese war there was always an insufficiency of equipment in this respect. In the infantry and artillery there were no telephones at all, or there were very few (two stations and 6 versts of wire per regiment, and sometimes purchased at the expense of the latter). The equipment pertaining to corps headquarters was withdrawn and put at the disposition of army headquarters, and the like.

We must regard the telephone as especially useful for regimental use while occupying positions within the divisions and between headquarters of neighbouring divisions. For the larger units it is preferable to employ the telegraph, because the possibility of talking by telephone with all the subordinate officers leads superior headquarters to wish to know everything and direct everything, and this to such an extent that there often results interference with the initiative of subordinates, a superabundance of orders, embarrassment, and even orders contrary to those of the immediate chiefs.

It is reported that an electric line between Chicago and St. Louis is contemplated. The present Illinois traction system, known as the McKinley route, will be the nucleus of the greater system.

The Design of Blast-Furnace Gas Engines in Belgium

By H. HUBERT

A Paper Read at the Recent Meeting of the Iron and Steel Institute.

THE first attempts at direct utilization of blast-furnace gas engines were made in 1895. For a considerable time the gas had been burnt in Cowper stoves for heating the blast for the furnace, and under the boilers which supplied steam to the blowing engines, and others serving the furnaces. It was natural, therefore, that the idea of directly employing it in gas engines should have occurred simultaneously to several engineers, notably to Lürmann and to Lencauchez, who had pointed out the blast-furnace as a powerful gas producer. Nevertheless, nowhere had any attempt been made to apply it to this purpose up to the end of 1894, when Thwaite proposed it to James Riley, of the Glasgow Iron and Steel Company.

About the same time investigations were being made in Belgium and in Germany, independently of Thwaite's experiments, which were not generally known on the Continent.

The industrial world, which up to that time had hardly favoured the idea, had thus been gradually prepared to receive it. The gas engine, long restricted to small sizes and dependent upon the use of an expensive fuel obtainable only in large centres, now began to make headway.

At the Paris Exhibition of 1889, two engines of 100 H. P. were shown, and excited much interest among engineers. One had four cylinders, and was made at the celebrated works of the Deutz Company, and the other was a single-cylinder engine, exhibited by two French designers, Messrs. Delamare-Deboutteville and Malandin.

In the meanwhile the design of gas producers had made important progress, completely freeing the new engine from its dependence on the gas works, enabling it to be installed anywhere, and to realize to the full extent its economic value by supplying it with a cheaper fuel.

In 1892 Delamare installed at the Moulins Leblanc works, at Pantin, a four-cycle, single-acting, single-cylinder engine, using producer gas, and developing 220 brake-horse-power, with a consumption of about one pound of coal per brake-horse-power per hour. Despite the difficulties met with in this bold attempt, it showed the possibility of economically producing high power with poor gas.

The time had now arrived for engineers to pay attention to the use of gas from blast-furnaces, which, although not of great heating value, was less costly, and was the more suitable on account of the progress which had been made in the design and working of blast-furnaces, the proportionally lower consumption of coke, and, as a result, the marked reduction in the relative quantity of combustible gases which only sufficed with difficulty to heat the blast and to produce the steam required about the furnaces. Finally, the progress of the science of heat had brought to light the causes of the low thermal efficiency of the steam engine, and notably of the loss resulting from the employment of boilers.

It is not therefore surprising that the idea of dispensing with the boiler, and burning the blast-furnace gases directly in the engine, occurred nearly simultaneously in three countries, where metallurgical industry had made great progress.

To Bailly and Kraft, of the Cockerill Company, belongs the honour of being the first in the field in Belgium. The patent taken out by the Cockerill Company for this new application was dated May 15, 1895, and the first trials were made at the end of that year. They were made with a "Simplex" engine of 8 H. P., in which it had only been sought to reduce the clearance space, in order to increase the compression and to facilitate the ignition of the mixture. The gas cleaning was very imperfect, and was carried out simply by passing it through two scrubbers four metres in height.

This engine displayed perfect elasticity and adapted itself to the variations of composition, pressure and temperature of the gases, giving an efficiency of 77 per cent.

The authors, in an article published in the "Annales des Mines de Belgique" at the commencement of 1897, described the results of the first trials, and the conditions necessary for the direct use of blast-furnace gases, showing that a plant producing 100 tons of pig per day was able to furnish about 18,000 cubic meters of gas per hour with a calorific value of 1000 calories. Taking into consideration that half this volume is available, and allowing for an efficiency of only 20 per cent. in the engines, the authors showed that it would be possible to obtain from these gases about 3000 H. P.

The small trial engine consumed about five cubic meters per brake-horse-power, which reduces the preceding figures to 1800 H. P.; but they foresaw at the time that this consumption would be ere long greatly reduced, and that blowing engines driven by gas would be built. They also foresaw that by disposing of the great surplus motor power, the blast-furnace would ultimately become a center for the production of energy for works surrounding, the boilers of which it would gradually supersede.

This remarkable progress was described by E. P. Martin, president of the Iron and Steel Institute, in his presidential address of 1897.

At the meeting of the institute on May 3, 1898, M. A. Greiner discussed the results published up to that time, which included the author's paper of February, 1897; a note by Galbraith and Rowden on November 18, 1897; one by Lenchauchez on November 8, 1897, and another by Lürmann on February 27, 1898.

Mr. Greiner combatted the objections which had been specially raised against this new method of employing gas by German metallurgists at the Düsseldorf meeting, and gave reasons for his belief that the consumption would be reduced below four cubic meters per brake-horse-power per hour, and that the blast-furnaces would be able, by superseding the steam boiler as an intermediary in the production of motive power, to place at the disposal of the engineer 20 H. P. per ton of pig produced daily.

Experience soon verified these forecasts. The Cockerill Company have constructed, with the collaboration of Mr. Delamare, a four-cycle, single-cylinder engine of the "Simplex" type, which in the twenty-four-hour trials, at which the author had the honour to collaborate with Professor A. Witz, gave one brake-horse-power for an average consumption of 3329 cubic meters, of a gas possessing a calorific power of 981 calories—say 3266 calories. (This figure has since been reduced to 3162.)

The principal dimensions of this engine are as follows:

Diameter of cylinder	0.800 metre
Stroke of piston	1 metre
Revolutions per minute	105
Indicated horse-power	2.3
Brake-horse-power	182

The construction of this engine is worthy of note. The cylinder proper is cast with a breech carrying at its lower portion the exhaust valve, and at the back a cylindrical prolongation, in which the admission valve is placed. This breech or cylinder head has its own water jacket and is provided toward the front with flanges bolted to the cylinder jacket, which was a part of the cylinder bayonet casing.

The shaft is not cranked, and carries a heavy flywheel. The piston is made in one piece and is not chilled. The pressure does not exceed seven kilogrammes (100 pounds). The sparking is effected by Delamare's system, in which a succession of sparks, produced by a Ruhmkorff coil, is emitted from a slide-valve on the back of the cylinder when its opening comes opposite to an orifice bored in the back. The movement of the sliding valve and similarity of the other valves is made by a crank and by cams keyed on to an auxiliary shaft parallel to the cylinder and revolving at half the speed of the main shaft. The governing is effected by the hit-and-miss arrangement by means of Delamare's air governor.

Starting is effected by turning the flywheel by a handwheel and by admitting a charge of carbureted air, the explosion of which starts the engine.

The success of this engine, which worked perfectly without the gas being cleaned as perfectly as is now done, and is still running after being eight years in service at Cockerill's, encouraged them to build a much more powerful type of engine, capable of directly operating a blowing apparatus of 600 H. P., and consequently of liberating the blast-furnace from its dependence upon the boiler.

Though the enterprise was considered rash, they still went on with the attempt, which was logically justified, seeing that in modern steam-driven blast-furnace installations the gas produced is only just sufficient for the requirements of the furnaces. To procure gas in excess it was necessary to commence by replacing the existing engines by more economical gas engines, for by such means only would gas be available. It is necessary to commence with gas-driven blowing apparatus. A motor of this description attracted much attention at the Paris Universal Exhibition of 1900. Another, coupled with its blowing apparatus, in the blast-furnace department of the Cockerill Company, and started up on November 30, 1899, was submitted to a series of trials on March 20 and 21, 1900.

The features of this remarkable engine were as follows: regulation by the method of hit-and-miss—that is to say, suppression of an admission of gas complete.

By Brake Tests—	
Diameter of cylinder	1,300 meters
Stroke of piston	1,400 meters
Revolutions per minute	94.4
Indicated horse-power*	786
Effective brake-H. P.*	575
Consumption per indicated H. P.-hour	2,556 cubic meters, or 2,515 calories
Consumption per brake-H. P.-hour	3,495 cubic meters, or 3,440 calories.
Tests with the Blowing Apparatus—	
Number of revolutions per minute	93
Indicated H. P.†	886.5
Effective brake-H. P.†	725
Consumption per indicated H. P.-hour	2,334 cubic meters, or 2,343 calories.
Consumption per brake-H. P.-hour	2,853 cubic meters, or 2,864 calories.

* With 89 per cent. admission and 11 per cent. hit-and-miss by the governor.

† Full charge without hit-and-miss.

The method of construction of the 200-H. P. motor had generally been retained, saving that the main bearings were separated from the cylinder casing, and were connected by four strong screwed steel stay-bolts, giving easy access to the piston. The shaft was cranked and rested on three bearings to support the flywheel, which weighed 33 tons. The piston-rod traversed the back cover in a stuffing box.

The admission valves were retained below like those of the exhaust. The admission of gas was carried out by separate valves placed in a valve box, separated from the cylinder by a third valve, called the mixture valve. The methods of working the valves and those of the ignition slide valve were retained. The regulation was carried out by hit-and-miss. The pressure attained nine kilogrammes per square centimeter (128 pounds). The circulation of water extended to the head and to the piston rod itself, to which the water penetrated by means of flexible pipes, which adapted themselves to its movement. The exhaust valve was also cooled. This was done with the object of preventing the ignition of the mixture by the dust, which, combining with the products of the decomposed oils on the piston or in the recesses of the explosion chamber, might form concretions retaining a temperature high enough to ignite the gases.

The arrangement of all the valves at the under side of the cylinder was such as to facilitate the sweeping out of the dust and decomposed oil, and to allow these large engines to work equally as well as the 200-H. P. engines without having recourse to a more perfect gas-cleaning process. This hope was ill-founded. It became necessary to interpose between the blast-furnace and the large engines of this class apparatus capable of reducing the dust held in suspension by the gas to 0.02 gramme per cubic meter. The means now used in Belgium are centrifugal fans with water injection and Theisen, Brian and Zschokke apparatus. The latter are not, strictly speaking, purifiers; they are, rather, coolers.

As they are not the invention of Belgian engineers it is not necessary to deal further with them.

As is well known, the novel idea of the Cockerill Company was vigorously discussed by engineers, who saw therein an economic mistake, and maintained that it was better to divide the power between two or four cylinders. The designers, nevertheless, knew perfectly well that they could obtain in this way, for a 600-H. P. engine, a more regular and perhaps more economical engine. They had already, however, studied the two-cylinder tandem types of 600 and 1200-H. P. One of Cockerill's licensees—Brietfeld-Danek, of Prague—had, since 1901, constructed a four-cylinder double-tandem engine of 600 H. P., giving remarkably even running; but Messrs. Cockerill wished to demonstrate that it was practically possible to develop 600 H. P. by means of a single cylinder alone, single-acting and of four cycles, and consequently to construct engines developing up to 2500 H. P. without exceeding four cylinders. In addition to this they were, moreover, anxious also to improve the governing, by applying to these large engines the principle of variable admission in lieu of the hit-and-miss governing, which required the use of heavy flywheels, and was not well suited for producing alternating electric currents, and needlessly strained the engine when it had to run continuously with reduced loads.

From 1901 they realized, with M. Delamare, that it was essential to obtain a variable-admission motor, an air governor, or else a centrifugal force, causing the double air and gas valves to open from the commencement of the suction stroke, but determining the closure earlier in the stroke as the power to be developed becomes lower.

In this manner the mixture admitted possessed the composition most favorable for complete combustion, but the volume admitted to the cylinder varied, and with it the pressure.

The ingenious mechanism which realized this mode of operation, which has been described elsewhere by the author,* was applied to a single-cylinder motor of 200 H. P. of the same dimensions as that of 1898.

The trials to which it was submitted in November and December, 1901, established beyond doubt a consumption varying between 3.318 and 3.455 cubic meters per brake-horse-power per hour for full load, the calorific value being 914 to 1017 calories. The expenditure in calories per horse-power varied between 3172 and 3434, and has been on an average nearly 3298—practically the same as that of 1898. At half-load it was on an average 4320 calories, and at quarter-load 7406 calories.

About the same time (1902) the Cockerill Company produced another engine, designed to give greater regularity with smaller dimensions—viz.: the double-acting engine.

It was well known that the first industrial gas engine—that of Lenoir—was double-acting, but the success of the Otto four-cycle and single-acting engine had, for a long time, relegated to the background all other types of engines. Nevertheless, M. Letombe, at the Brussels Exhibition, showed a four-cycle and double-acting engine.

The Körting Company exhibited at Düsseldorf a powerful two-cycle double-acting engine which attracted much attention. The long-standing prejudice against the adoption of this system was thus broken down.

The direct driving of the blowing apparatus from the piston rod of the engine had accustomed Cockerill's engineers to the adoption of a stuffing box at the back end of the cylinder. They were therefore naturally disposed to adopt double action, which enabled them to considerably reduce the size of the cylinder, and consequently approach large powers more easily, thus ensuring more steady running with a lighter flywheel.

* *Revue Universelle des Mines*, 1902, vol. lix.

They retained, firstly, the general arrangement of the single-acting motor, which up to that time they had constructed, notably the disposition of the inlet and exhaust valves underneath the cylinder. However, from that time they introduced an important modification. The cylinder liner with its jacket constituted a part independent of the two cylinder heads. Each of these carried a stuffing box, through which the water-cooled piston rod worked, and an extension downward of the combustion chamber, in which was installed the valve, which simultaneously admits air and gas, and actuates the exhaust valve. The actuating mechanism of the valves was also modified, without departing from the system of variation of the admission, consisting of cutting off the air and gas supply simultaneously. This system had the advantage of preserving the composition of the mixture most favorable to complete combustion, but it had the inconvenience of diminishing to some extent the compression as the charge decreased. This diminution reduced the economic efficiency of the engine in the case of light loads; and also when it happened that the gas was very poor it spoilt the ignition and caused misfires, which altogether upset regularity and economy.

This trouble becomes very marked in motors driving dynamos, which very often work with reduced loads, and where economy is a greater consideration than in blowing engines. Therefore, no time was lost in introducing another system of variation, consisting of air admission to the cylinder during the whole piston stroke, and only allowing the gas to enter during the last portion of the stroke by the governor varying the moment at which this admission commences. In this way invariable compression is secured.

It is true that when the mixture is modified it becomes poorer and poorer; but it should be noted that gas is introduced at the back end of a cylinder already partially filled by a volume of air which follows the piston. Although it is impossible absolutely to rely upon retaining the exact stratification characteristic of the Otto cycle, there persists, nevertheless, an undoubted stratification of mixture, the richest strata remaining at the back end of the cylinder, close to the ignitor.

The sparks then impinge on the explosive mixture, which, being strongly compressed, ensures that the ignition is readily transmitted to the whole volume. It will be seen that the gas-admission valve must be able to open independently of that giving air admission.

In engines of this system the two valves are superposed, the air arriving by a casing which surrounds the gas passage, and the valve spindle passing through the gas valve, which is hollow. The placing of the valve in an ante-chamber of the combustion chamber, leading to a tubular combustion chamber, evidently assists the stratification of which mention has been made, and consequently the ignition of weak charges, but it resulted in cylinder heads of unsymmetrical form, which created difficulties at Cockerill's works, as it had already done elsewhere.

The unequal contraction of the metal of the various parts of the cylinder head causes great stress, which, added to the already high stresses, due to the explosion and to the heating, have occasionally brought about the fracture of the cylinder heads, even when they have been replaced by steel castings.

This circumstance decided the makers of large engines to revert to the symmetrical arrangement of the valves, which is customary in steam engines where the inlet valve is placed on top of the cylinder, and that of the exhaust underneath, and thus to obtain an arrangement which lends itself well to expansion, and which, moreover, facilitates access to the valves.

This arrangement has been obtained in different ways by manufacturers, notably at the works at Deutz and Nurnberg and at Seraing. At the Cockerill Company's works the covers are no longer attached to the central body by studs screwed into it, but joined by tie-bolts bolted to flanges on these covers.

These bolts are thus subjected to tension, and, similarly, the body of the cylinder is subjected to a compression stress of the kind which best suits such metal. This arrangement is patented. The frame is formed of two box girders carrying the cylinder. These girders are joined by tie-bolts to others that contain the slides and carry the crank-shaft bearing. The piston is composed of two halves with double walls, each half permitting water circulation, the two halves being bolted together with an india-rubber joint.

The water cooling is effected at a pressure of three and one-half to five kilogrammes (fifty pounds to seventy pounds) per square centimeter, to avoid water-hammering in the piston and its rod. The water, furnished to the latter by a duct fixed at one end, passes through the rod and the two halves of the piston, and goes out at the back by another duct.

The ignition is effected by means of one or two high-tension magnetos, through fixed sparking-plugs. These magnetos do away with the necessity for a source of electricity external to the motor. The compression has been successively increased up to fourteen kilogrammes per square centimeter. The starting is effected by means of air, compressed to ten atmospheres (143 pounds) by a special compressor, and retained in a reservoir in sufficient quantity to enable the engine to revolve several times.

The Telephone in Railroad Service

A RAILROAD can, without large outlay, according to H. L. Burdick and W. T. Saunders, in "The Railway Age," gradually cover its whole system with telephone circuits. When it is considered that the telephone does not require expert knowledge of telegraphy, and that in case of differences with organized labour, the roads can manage to continue operating, it would seem that the telephone is becoming a necessity to the railroad and cannot much longer be denied a place in operating.

The question of whether a railroad should own or rent its telephone sets, for private line use, does not enter into the problem to any great extent. If a railroad pays $12 for a set of telephone instruments,—the life of which, for railroad private line use, is six years,—the road must lay aside $2 per year, on the original cost, to pay for the set. There is also a charge of 5 per cent. on the investment, or 60 cents per year. Beyond this, there is the replacing of broken parts of instruments, which, taking into consideration the fact that these sets, on private lines in yards, are subjected to comparatively rough usage, cannot be less than 5 per cent. on the original investment. This amounts to an additional 60 cents per year. As a total, then, the railroad pays $3.20 per year for each set owned.

If these sets are owned by the road they cannot at present be connected with the general public, nor with the majority of railroads, for the majority of roads rent their telephone sets. The road must also take into account the fact that the sets owned, if destroyed by fire, flood or any other cause, are a total loss, while sets, if rented, must be replaced by the telephone company.

In whatever manner the telephone is adopted by the railroad company, it would seem that the facility of reaching the public, the saving in the handling of yards, the possibility of combining the telegraph circuit and the telephone circuit, the added facilities for train movements, the making-up of freights, and lastly, the exemption from tie-up on account of organized labour, would render it indispensable that live railroads be, within a few years, fully equipped throughout their entire systems with telephone facilities.

Power from Waste Gases in Great Britain

IN his address at the fiftieth anniversary meeting of the German Society of Engineers, Dr. H. Hoffman, of Bochum, estimated that 500,000 H. P. could be obtained by the proper utilization of coke oven gases now wasted and 1,000,000 H. P. from blast furnace gases, if used to drive gas engines.

H. E. Wimperis, by a similar calculation in an article in the London "Times" Engineering Supplement, estimated that in Great Britain coke oven and blast furnace gases now wasted could be made to develop 1,000,000 H. P.—300,00 H. P. from the former and 700,000 H. P. from the latter. He says: "So far little has been done in this country, but with the keen interest now taken in every development connected with the internal combustion engine it is not likely that the metallurgical industries here will remain blind to anything which affects so strongly their own interests. Probably the results obtained at the Shelton Iron & Steel Company's Works, where it is understood that a plant of about 700 H. P. has recently been put down to deal with coke oven gases, will, when the details are published, operate largely to bring others in this country to a decision for or against the speedy introduction of such engines in their own works."

The third-rail electric cars of the New York, New Haven & Hartford Railroad, which have been running between Hartford and Bristol for several years, were taken off the first of August. This action was as a result of a decision of the Superior Court in a suit brought by or on behalf of citizens of New Britain complaining of the third rail. The track used by the electric cars will be restored to its former use as one of the two lines of a double track for steam trains.

The Wireless Telegraph Stations of the World

THE wireless telegraph stations of the world, 265 in number, have been catalogued by the Bureau of Equipment of the United States Navy Department, and the list will be published in a small book. The various systems of space telegraphy used are also given in each case.

According to this authority, the number of stations in each country is: United States, 88 (of which 10 are in the possession of the United States and 32 are directly under the control of the navy); United Kingdom, 43; Italy, 18; Germany, 13; Belgium, 1; Denmark, 4; France, 6; Holland, 8; Spain, 4; Portugal, 1; Gibraltar, 2; Malta, 1; Montenegro, 1; Norway, 1; Austria-Hungary, 2; Roumania, 2; Russia in Europe, 8; Sweden, 3; Turkey, 6; Argentina, 5; Brazil, 5; Canada, 5; Chile, 1; Costa Rica, 1; Mexico, 2; Panama, 2; Uruguay, 1; Trinidad, 1; Tobago, 1; Audaman Islands, 2; Burma, 1; Hong Kong, 1; China, 5; Hawaii, 5; Japan, 2; Dutch East India, 5; Russia in Asia, 1; Egypt, 2; Morocco, 2; Mozambique, 2, and Tripoli, 1.

Beginning August 1, the New York Central Railroad has been conducting a school for the instruction of engineers in the handling of its new electric locomotives and suburban cars. By October 15, it is expected, through passenger trains will be hauled by electric locomotives between the Grand Central Station and Kingsbridge on the main line and suburban trains will be operated by the mutliple-unit system as far as Kingsbridge on the main and Wakefield on the Harlem division. This will give two months in which to thoroughly familiarize employes with the handling of electric locomotives and cars. In choosing crews for the electric zone preference will be given to the present enginemen and firemen. The company will not attempt to give its employes an insight into the technicalities of electric operation, but will merely give them practical instructions in the operation of the electric equipment. In the course of a recent test at Schenectady one of the company's steam locomotive engineers was given a half hour of instruction and then placed in charge of the New York Central electric engine No. 6000. In a race with the Empire State Express the electric engine outdistanced its competitor, was slowed down by the new engineman and then allowed to overtake the express again.

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Train Resistance and the Fuel Relations Between Heavy Steam and Electric Traction

By WM. S. MURRAY, Chief Electrical Engineer, the New York, New Haven & Hartford Railroad

THE fuel bill, although by no means occupying the largest percentage of the total operating cost either of a steam or electric railroad property, yet, as a part to be integrated into the whole, is one that commands immediate respect and attention. Locked within the limits of a pound of coal are from 11,000 to 15,000 British thermal units, each one of which is effective, in part, for the movement of trains. This is true whether the trains are operated by steam or electric locomotives, and it follows that the system of the highest commercial efficiency of transmission from heat energy into traction energy is the one operating at a minimum fuel cost.

A word on commercial efficiency before proceeding further. Truly it is better to send one dollar after two dollars than the reverse, yet as often do we see the latter done. At times one hears a fierce animadversion upon the alternating-current railway motor because its efficiency is, perhaps, inherently 2 per cent. less than its direct-current brother, but from the same voice we hear little about the fixed charges constantly demanding financial tribute from the 1,000,000 c. m. cable that is feeding the latter, and less about the 4/0 wire feeding the former.

True commercial efficiency may be defined as a great chain of engineering and commercial considerations. From a purely engineering standpoint, were we to consider only one link of this chain, we might wonder why a piece of apparatus was deliberately chosen of an acknowledged lower rather than a higher efficiency; but as surely as we know that a chain must have more than one link, as surely should we look to see, first, what holds this link, and, second, what this link holds, and so follow the chain both ways to its ends. Then, and only then, are we in the position to criticise,—not before. This definition of commercial efficiency, its analogue, and the preceding illustrations, are offered in an endeavour to present a fair and firm platform on which the broad-minded commercial and technical engineer can stand.

In the problem of electrification of the New Haven road there was no middle link upon which to perch and travel both ways to its ends in order to criticise and improve. The chain had to be forged all but its first link,—the coal pile,—and the foregoing remarks concerning the matter of commercial efficiency are pertinent to those following, since the real essence of this article is to show that the electric system of traction we have adopted is the one in which $1 worth of coal will produce a much greater hour rate of doing work at the rims of the locomotive drivers.

It is the writer's belief that a careful investigation would show that over 90 per cent. of the watt-hours put out for electric traction in this country are primarily generated on a coal-steam basis. It is the system adopted by the New York, New Haven & Hartford Railroad Company; and as the constants that enter the chain of efficiencies for both the steam and electric locomotive traction are well known, these, together with other data collected, afford an interesting study of probable results to be attained. The article naturally divides itself into two departments, as follows:—

First.—The actual resistance of the division over which steam and electric traction are to be considered.

Second.—The determination of:—

(a) The number of ton-miles the steam locomotive will haul.

(b) The number of ton-miles the electric locomotive will haul, when for each locomotive the same amount of money is expended for coal.

It is to be noted that we are not considering equal amounts of coal burned, but equal amounts of money expended for coal, by which distinction we note immediately one of the commercial links in the efficiency chain.

We are supplied with much data concerning the performance of locomotives. Many elaborate tests have been made in which are recorded the number of pounds of coal burned per indicated horse-power-hour. These tests have been conducted both in the shop and on the road, and are of inestimable value, as far as they go, to show the operating characteristics of individual locomotives.

The data furnished, however, are insufficient in estimating the actual coal consumed by mileage under real commercial schedule. It does not concern a company,—except that it is wise to use the most economical locomotive,—that a locomotive burns a given amount of coal per indicated horse-power-hour while that locomotive is making its schedule of revenue miles. These revenue miles may be made in three, six, nine or twelve hours in a day.

To get the actual amount burned, we must finish the day in each case, and not only note the total amount of coal burned for revenue miles run, but the amount burned while the locomotive was idle, yet still holding steam pressure. This amount of coal burned for the 24 hours very materially concerns the company.

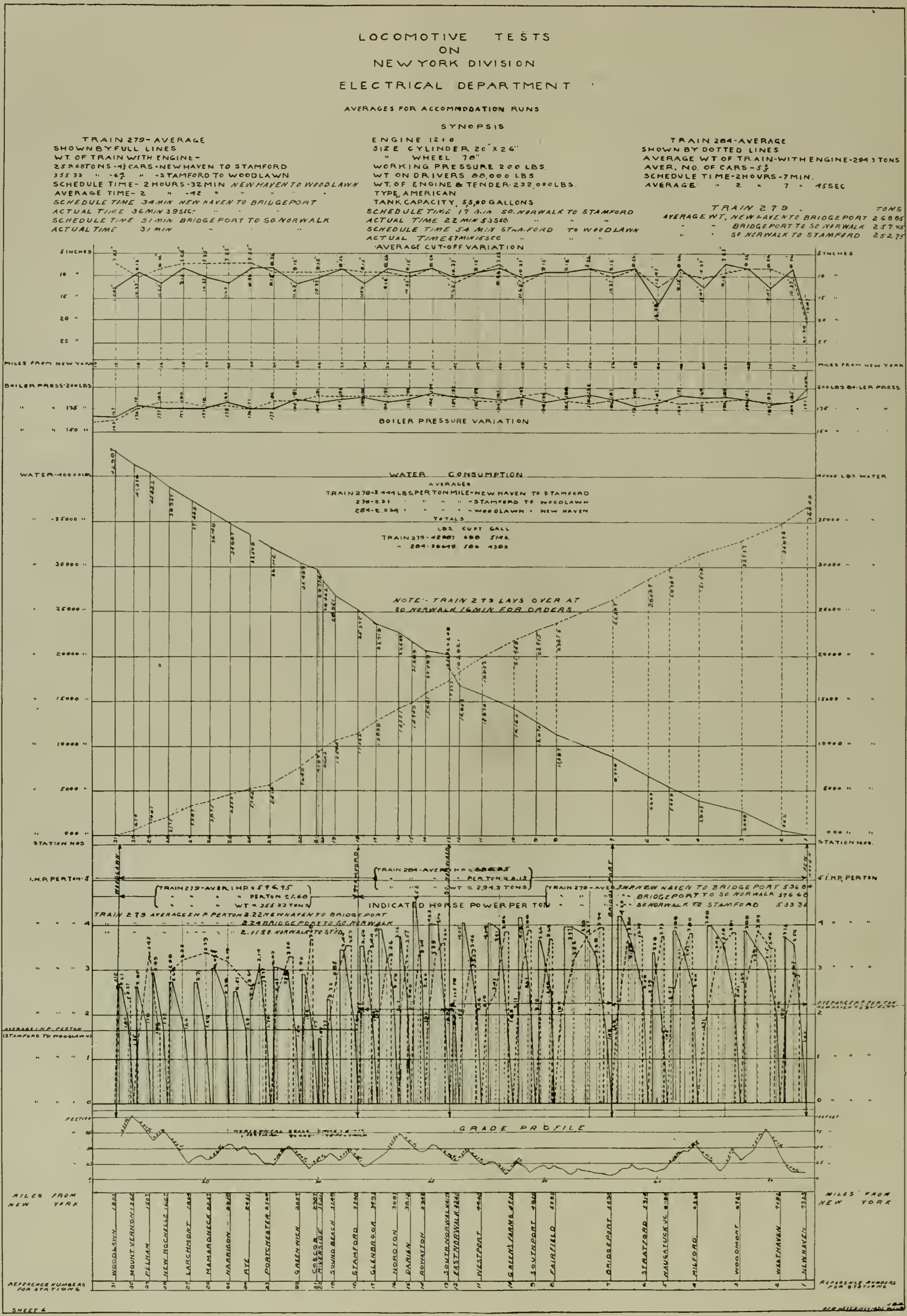


FIG. 1.—TRAIN RESISTANCE AND FUEL DATA OF A LOCOMOTIVE DRAWING AN ACCOMMODATION TRAIN BETWEEN WOODLAWN AND NEW HAVEN

Over a four-track system 73 miles in length, varying in grade and curvature, it is obvious that the resistance also varies greatly. It was apparent, therefore, that to take a few indicator cards on various parts of the division, with locomotive speeds varying from 10 to 30 per cent., would not furnish a reliable data upon which to base conclusive records of average indicated horse-power. It was equally apparent that the more indicator cards that could be taken throughout the entire resistance run, the more reliable would be the figure obtained for the average indicated horse-power developed.

After a conference with the company's mechanical engineer, the writer became convinced that 66 per cent. of the total distance between Woodlawn and New Haven could be indicated, and that, further, after several of these complete runs had been made, by superimposing them upon each other for an average value, practically the whole division would be indicated for its resistance. The following scheme of indication was adopted:—

(a) One minute allowed for changing cards on steam indicator.

(b) Six diagrams per minute to be taken on the same card.

(c) Two minutes to be devoted to taking cards.

(d) Interval between cards, 20 seconds.

It will be noted that by this method on each indicator card were obtained twelve indicator diagrams,—six for each end of the cylinder. The average mean effective pressure of these six cards was taken to secure the indicated horse-power for the cycle of three minutes above described. This three-minute cycle of 66 per cent. card indication was practiced for several days until perfect runs were secured between Woodlawn and New Haven, east and west. Then five continuous east and west runs were made for express and local service, and an average curve of each class plotted. These curves are shown in Figs. 1 and 2.

The data on the test sheets referred to are self-explanatory. Much of these data do not concern this article, though all have a relative bearing to the indicated horse-power calculated. In particular is the water consumption curve interesting in its cumulative course as the indicated horse-power-hours were reeled off.

The apparatus used in making these tests was of a simple character, consisting in the main of a steam indicator, a simple reducing motion, two hot-water meters, a locomotive speed counter, and the ordinary equipment common to steam locomotives. At this point the writer must mention the excellent services of Messrs. A. L. Roberts, W. J. O'Meara, and J. M. Morse, all of the New York, New Haven & Hartford Railroad Co., whose stations were on the locomotive, either behind the wind shield or on the cab, and whose careful attention to detail during the work of indication and observation gives the real value to the results obtained. It is needless to add that on a swaying locomotive, at a speed of 60 miles an hour, in a blistering temperature, it is not an easy task to take six indicator cards in two minutes, and in the next minute get ready for another cycle. So much for the method adopted to secure the average indicated horse-power.

Concerning the matter of the amount of coal burned, a review of the means at hand showed that by a simple, thoroughly understood and well-organized plan of co-operation between the several departments of the company interested, accurate and reliable results could be obtained. To the end of calculating the 24-hour, or what may be called commercial, economy, the operating department provided, for test purposes, 20 locomotives, 10 freight and 10 passenger, all operating on regular schedule, and coaling at regular points.

The fuel department supplied each engine with an individual coal car, and for a period of eighteen days the exact weight of coal each locomotive burned was determined. Over the above period of eighteen days the car service department kept an account of the number and weight of cars each locomotive hauled, and the actual mileage over which these weights obtained. The department of the mechanical superintendent kept an account of the mileage of each locomotive.

Three general classes of service were considered, as follows:—

(1) Express. } Passenger.
(2) Express-Local. }
(3) Freight.

Thus an accurate record of the weight of coal, the train weights, and the miles covered in the three above-mentioned services, furnished the necessary data to determine the pounds of coal burned per ton-mile. These are shown in Tables I. and II.

In these tables one locomotive has been omitted from the express runs, as it was clear from the other values received that this locomotive was very inefficient, and indeed was shortly ordered to the shops in virtue of the developed fault.

A LOCOMOTIVE FITTED WITH A WIND SHIELD FOR PROTECTION WHILE INDICATOR CARDS WERE TAKEN

Also in the table of local-express tests, the records of two locomotives have been omitted, in view of schedule requirements necessitating their operating on other divisions. Although complete data were secured, they have been omitted, in view of the fact that the operation of these locomotives was not entirely upon the New York division.

In the schedule of freight engines, it may be noted that two locomotives have not been included, and again, while we have as complete a record of these as of the other locomotives, the results proved the locomotives to be so inefficient as to make it advisable to exclude their records from the averages obtained.

Ten per cent. of total car weights has been added to cover the weight of passengers. From the above-

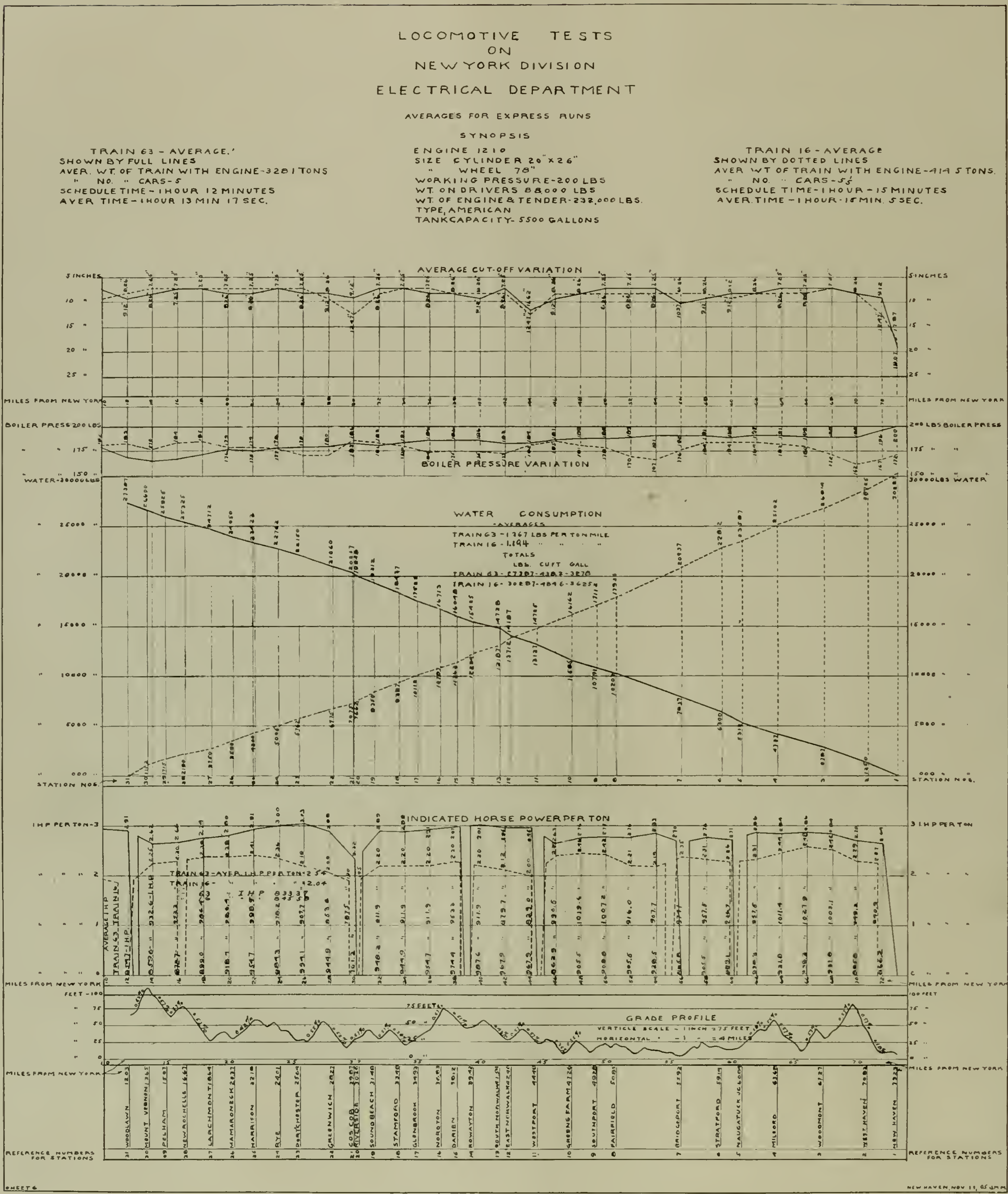


FIG. 2.—CURVES SHOWING FUEL AND WATER CONSUMPTION OF A LOCOMOTIVE DRAWING AN EXPRESS TRAIN BETWEEN WOODLAWN AND NEW HAVEN

stated conditions, it is to be observed that the steam locomotive is accorded every possible favour, in order to be on the safe side.

Referring to Table I., it will be noted that the average amount of coal per ton-mile of express service is 0.194 pounds; for local express service, 0.335 pounds; for freight service, 0.169 pounds. By multiplying the total number of ton-miles of these three services operated over the division by their respective coal constants, as above calculated, the sum of the three products thus obtained should, and will, give a very close check on the amount of coal which will be burned on the division for which the calculations and measurements were made. It is of importance to note the very small difference in ton-miles between columns 5 and 8 in Table I., showing practically no switching done by the locomotives.

TABLE I.—EXPRESS PASSENGER SERVICE.

No. of Locomotive.	Mileage of Locomotive in 18 Days.	Pounds of Coal Burned in 18 Days.	Average Weight of Train Including Locomotive and Passengers.	Total Ton Miles of Train Including Locomotive, Passengers and Switching for 18 Days.	Total Horse Power Hours for 18 Days of Locomotive in Revenue Service Based on Average H. P. Between Woodlawn and New Haven.	Pounds of Coal per I. H. P. Hour Based on Average I. H. P. Between Woodlawn and New Haven.	Total Revenue Ton Miles of Train Including Passengers and Locomotive for 18 Days.	Pounds Coal per Revenue Ton-Mile.	Pounds Coal per I. H. P. Hour by Average Ton-Mile Method.
832	2,782	301,384	573.5	1,556,730	73,100	4.12	1,545 000	0.195	4.40
841	2,336	215,830	480.7	1,123,050	53,150	4.06	1,123,000	0.192	4.34
Average	2,559	258,607	527.1	1,339,890	63,125	4.06	1,334,000	0.194	4.37
LOCAL EXPRESS PASSENGER SERVICE.									
1262	3,160	295,038	303.0	914,330	63,900	4.62	894,000	0.330	4.54
1258	2,644	264,138	302.2	795,182	57,000	4.64	794,500	0.330	4.54
1272	3,482	353,396	351.5	1,147,520	80,000	4.42	1,114,000	0.317	4.36
1571	1,890	187,180	307.8	577,929	40,600	4.61	566,000	0.331	4.55
1574	1,938	216,583	306.4	593,838	42,500	5.10	593,000	0.366	5.04
Average	2,623	263,267	314.2	805,760	56,800	4.68	792,300	0.335	4.61

TABLE II.—FREIGHT SERVICE

No. of Locomotive.	Mileage of Locomotive in 18 Days.	Pounds of Coal Burned in 18 Days.	Average Weight of Train Including Locomotive.	Total Ton-Miles of Train Including Locomotive for 18 Days.	Pounds Coal Per Ton-Mile.
300	1,557	230,376	930	1,446,868	0.159
301	1,153	184,836	661	761,755	0.242
325	1,592	231,366	696	1,108,615	0.209
373	2,010	237,006	1,060	2,129,575	0.111
382	2,018	304,044	1,240	2,495,072	0.122
386	1,274	220,680	731	930,792	0.237
448	2,272	413,106	1,255	2,850,046	0.145
453	2,350	255,444	872	2,053,142	0.124
Average	1,778	259,607	931	1,721,983	0.169

Having determined the amount and cost of coal burned on a division with steam traction, we are immediately interested to know the amount and cost of coal burned on that division when operated under electric traction, the ton-mile haulage being the same in each case.

Again referring to Table I., it is to be noted that two results are recorded as the amount of coal burned per indicated horse-power-hour, the first based upon the "average indicated horse-power-hours between Woodlawn and New York," the second based upon the "indicated horse-power-hours by average ton-mile method." It is to be noted further that, in the case of the express service, the first figures show a better economy, while in the case of the local express service the figures are reversed, the better economy being noted in the second method.

These two methods were selected as a check upon each other, and the resulting differences anticipated. An explanation of their difference is simple, in view of the fact that, for express service, the reduced speed between Woodlawn and Forty-second street, in New York, would call for a rate of expenditure of coal less than the average rate between Woodlawn and New Haven, while for express local service, due to a speed between Woodlawn and Forty-second street higher than the average speed between Woodlawn and New Haven, the coal rate would naturally be increased. With this explanation the first method is obviously only an approximation, and the second method may be taken as bearing out the actual results. It is of passing interest to note, however, how closely the two methods check.

These calculations thus determine the real practical economy of locomotives doing an express and local service.

The discussion of the two efficiency chains, first, that of the steam locomotive, and second, the electric locomotive, is now in order. In this discussion we note with which system a pound of coal goes the farthest. The unit of measurement can be taken as the horse-power-hour delivered to both the steam and electric locomotive for both the express and local service.

STEAM LOCOMOTIVES

Express service.—

By figures in the foregoing it is shown that the pounds of coal per horse-power-hour are 4.37, and of these an average of 85 per cent. (efficiency of locomotive) are turned into useful tractive effort, increasing, therefore, the coal rate at the rim of the driver to 5.14 pounds per horse-power-hour.

Local Express service.—

In the same way for local express, 4.61 pounds of coal are obtained per indicated horse-power-hour, or 5.43 pounds at the rim of the driver.

ELECTRIC LOCOMOTIVE

Express service.—

Pounds coal per switchboard horse-power-hour, 2.10 pounds.

Average efficiency of line, 95 per cent.

Average efficiency of transformer, 95 per cent.

Average efficiency of motors, 87 per cent.

Pounds of coal per horse-power-hour at rim of drivers, $\frac{2.10}{0.95 \times 0.95 \times 0.87} = 2.67$ pounds.

Local Express.—

Pounds of coal per horse-power-hour at rim of driver, as before, 2.67 pounds.

It is, therefore, noted that a pound of coal delivered under the boilers of the power station produces 93 per cent. more horse-power-hours for express service than the same pound delivered under the boiler of the locomotive; or conversely, the same express ton-mileage by the electric method of traction is produced with 52 per cent. of the coal required when trains are moved by steam locomotives. For express-local service these become 103 and 49 per cent., respectively.

An investigation of the total number of ton-miles moved per annum on the division for which these calculations were made, is indicated in

TABLE III

	Ton-Miles per Annum	Tons of Coal Steam Traction	Tons of Coal Electric Traction	Cost of Coal Steam Traction	Cost of Coal Electric Traction	Saving of Electric over Steam Traction
Express	592,240,000	57,447	29,870	$183,830	$89,620	$94,210
Express Local	348,000,000	58,300	28,600	186,560	85,800	100,760
Express-Freight	2,223,000,000	187,844	139,010	563,530	417,030	146,500
						$341,470

the following tabulation, in which also is shown the coal consumed by the two methods of traction.

In the place of taking steam indicator diagrams on the freight locomotives, the rather high figure of 35 watt-hours per ton-mile for an average speed of 18 miles per hour has been used to show the difference in coal consumption for this class of service. Thirty-five watt-hours per ton-mile reduced to horse-power units become 0.0469 horse-power-hours. The coal measurement showed that an average of 0.169 pound of coal was being used per ton-mile, thus giving the figure of 3.604 pounds of coal per horse-power-hour for coal consumed by the steam traction method. As the same chain of efficiency applies for freight service in electric traction as in passenger service, the ratio of 2.67 to 3.604 shows that by the electric traction method the same ton-mileage can be moved for 74 per cent. of the amount of fuel required for steam traction, which is indicated in Table III.

In the saving effected, as shown in Table III., it is to be noted that for freight service, due to more feasible points of coaling, the locomotives receive their coal on the tenders at the same rate as coal delivered under the boilers of the power station, this figure being $3 per ton. Due to the necessity of extra handling, this figure becomes $3.20 per ton in passenger service.

A word in conclusion. The figures in the foregoing are a discussion of the economies to be effected entirely within the limits of the coal pile. It has been the effort to show every favour to the steam side, and thus play safe for the results to be attained in actual practice. On fuel alone, therefore, we note a saving of $341,470 per annum.

Capitalizing this saving upon a 4 per cent. basis produces a figure of $8,537,000,—not a small percentage of the total investment,—and as we have yet to open up the record of further economies secured by virtue of less equipment and track maintenance charges, both of which are an interesting story in themselves, it is the writer's belief that high-tension electrification will not only do away with dirt and cinders, but will produce the results in which not only the engineering world are interested, but also the sound-minded, practical business men behind whom and by means of whom the demonstration be made possible.

An interesting check on these figures is the actual per annum fuel bill covering coal for the New York Division, and I find that it agrees substantially with the figures as shown in the fourth column of Table III. It should be added, however, that the high single-phase efficiency upon which the electrical figures are based does not obtain over that portion of the line between Woodlawn and New York, where, by reason of conversion from alternating to direct current, a heavier loss results; but as the ton mileage over this section is but a small percentage of the total, the figures will not be affected to an extent greater than 5 per cent.

The Schenectady Branch of the American Institute of Electrical Enginenrs

PROMISE of great activity on the educational and social side of Schenectady's electrical workers was given at a well-attended meeting of the branch of the American Institute of Electrical Engineers, held on Saturday evening, September 8. The gathering, at the fraternity house of Alpha Delta Phi on Union College campus, was in the nature of an informal smoker, and plans were discussed for the ensuing year.

During the evening addresses were made by Prof. C. P. Steinmetz and by David B. Rushmore, the chairman of the branch. The speakers outlined the suggested programme for the winter, which includes not only the regular monthly meetings, as heretofore, but a course of Saturday evening lectures has been arranged, and already over thirty prominent engineers, many of them from outside of Schenectady, have accepted the society's invitation to speak.

Prof. Steinmetz, in his remarks, recalled the early days of the General Electric Company, so well remembered by the older engineers, when a close acquaintanceship and exchange of ideas was possible between the experienced men and the beginners. The immense growth of the business has so segregated the members of the different departments that this intercourse is no longer practical, a condition greatly regretted by those who appreciated the advantages derived on both sides from the former closer relationships.

It is, therefore, intended to make the lecture nights not only of an instructive nature, but to furnish thereby an opportunity for social gatherings where acquaintances can be made between the local engineers, the students in the colleges of Schenectady and Troy and all others interested in electricity and its applications.

In order to stimulate interest in these meetings, free trips to New York to attend the monthly meetings of the national association, the American Institute of Electrical Engineers, will be given to those who take a conspicuous part in the discussions or otherwise contribute to the success of the branch. A neat prospectus, outlining the proposed work, was distributed at the gathering Saturday evening, and the general expressions of approval the plans received leave no doubts as to the success of the undertaking.

E. B. Merriam, of the General Electric Company, is chairman of the membership committee, and is already getting busy enrolling new members. A special membership, with dues one-half the regular branch dues, is proposed for all men in the General Electric testing department, the American Locomotive Works testing department, Union College and the Rensselaer Polytechnic, of Troy.

Water Power in Wisconsin

IN a recent bulletin, Chief Hydrographer Leighton, of the United States Geological Survey, says that much interest is shown at the present time in water power development in the State of Wisconsin. A single firm of engineers has received during the past year over thirty applications from clients for preliminary plans for water-power plants. Many of these projects contemplated the transmission of power a considerable distance by electricity.

The United States Geological Survey, which is measuring the flow of streams in all parts of the country, is carrying on in Wisconsin as much work as the available funds will permit. Surveys of streams are being made in co-operation with the State, and river gauging stations are being maintained at the following points: Black River, at Neillsville; Chippewa River, at Chippewa Falls, and Eau Claire; Flambeau River, at Ladysmith; Oconto River, at Gillett; Peshtigo River, at Crivitz; Wisconsin River, at Merrill; Necedah and Rhinelander' and Wolf River, at Shawano.

In speaking before the British Association of the growth in business on railways due to electrification, C. F. Jenkin said that in 1901 the trams on the west side of London were electrified, and in three years, while the mileage was increased fourfold, the traffic increased seven and a half times. The Manhattan line in New York was electrified the same year. In the first year after electrification the traffic increased 50 per cent., and the cost of working fell from 55.79 to 41.2 per cent. of the gross receipts. The Milan-Gallarate-Verese line was also electrified in 1901, and in three years the number of passengers carried increased 170 per cent. On the North-Eastern Railway, at Newcastle, the traffic on the electric lines has increased 25 per cent., and the receipts have gone up from $645,000 to $755,000, while the costs have only risen from $213,805 to $238,895.

Some European Hydro-Electric Plants

By FRANK C. PERKINS

FIG. 1.—PART OF THE TRANSMISSION LINE IN SWITZERLAND, FROM GIUBIASCO TO BELLINZONA

IN Switzerland and Italy during the past decade engineers and financial interests have awakened to the advantages to be gained by the development of the water power available, and during the last two years a number of plants have been installed and schemes projected for utilizing in various cities electric power transmitted from these stations.

One of the Swiss plants is that erected on the Marobbia River, which joins the River Tessin at Giubiasco. Electric current is utilized for light, heat and power in the city of Bellinzona, about two and one-half miles from the power station. In several sub-stations in the city are installed step-down transformers, and the villages of Castione and Giubiasco also are supplied with current transmitted to sub-stations. Iron poles of the lattice-work type are used on the transmission line, the conductors being mounted on triple-petticoat insulators. Following current practice, the switching apparatus of this power plant is mounted in a separate room. The switchboard faces the generator room and is installed in a gallery.

Three-phase, 50-cycle current at 5350 volts is supplied by three 490-KW. generators constructed by the Societie d'Electricité Aloeth, of Lyons and Münchenstien (Bale). These machines are of the 12-pole type shown in the illustration, with a 2-pole exciter mounted outside of the main bearings of the alternator, and supplying an exciting current at 43.6 volts. The three-phase machines are driven at 500 revolutions per minute by tangential wheels, 4½ feet in diameter, and constructed at Zurich, Switzerland, by Escher, Wyss & Co.

From the intake a conduit is blasted out of rock for a distance of

FIG. 2.—INTERIOR OF THE HYDRO-ELECTRIC PLANT ON THE MAROBBIA RIVER IN SWITZERLAND. CURRENT IS GENERATED BY THREE 490-KW. MACHINES AT 5350 VOLTS

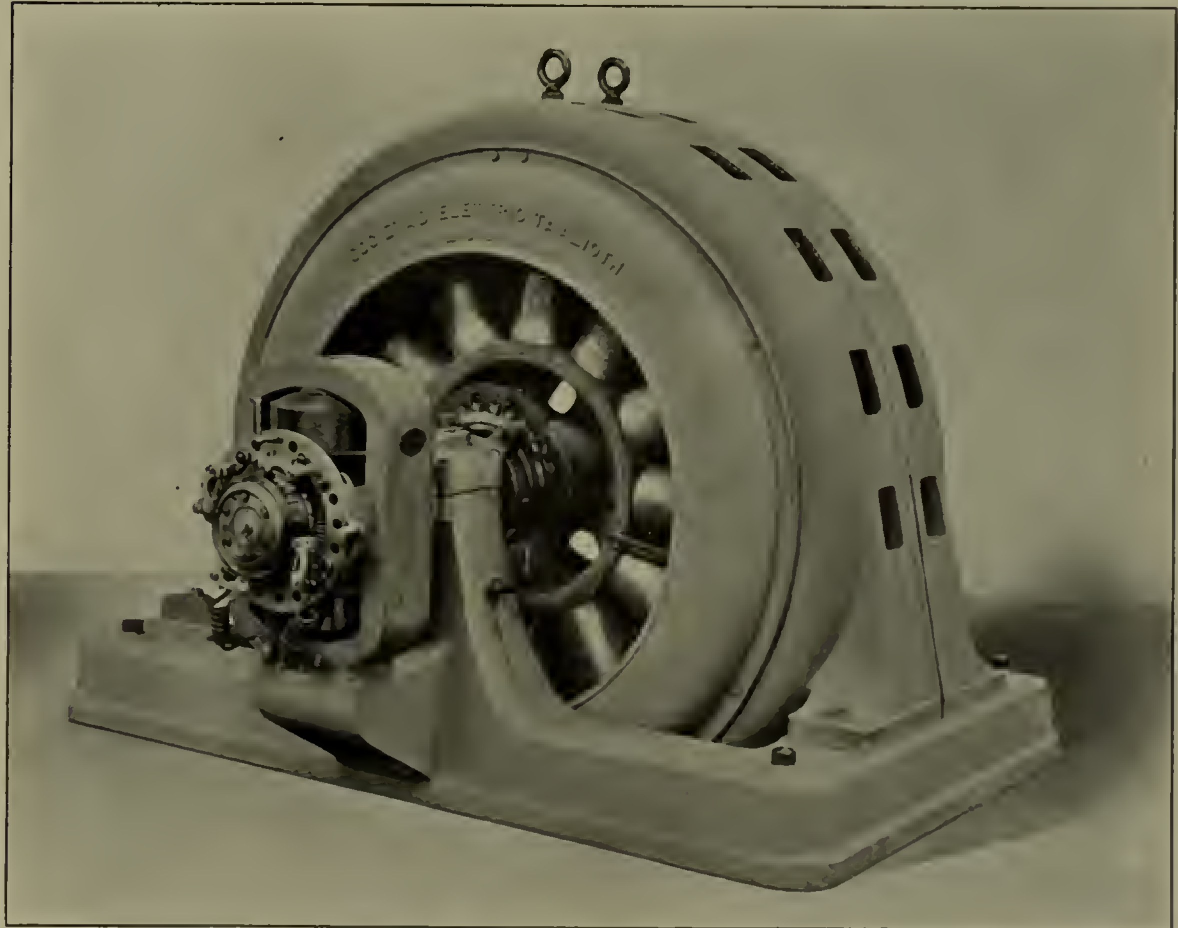


FIG. 3.—ONE OF THE GENERATORS IN THE MAROBBIA RIVER PLANT. A TWO-POLE EXCITER IS MOUNTED OUTSIDE THE MAIN BEARING

FIG. 4.—THE END OF THE CONDUIT FROM THE MAROBBIA RIVER AND THE GATE HOUSE FROM WHICH THE PENSTOCK CONVEYS THE WATER TO THE POWER PLANT

FIG. 5.—BUS-BARS IN THE VENICE SUB-STATION, WHICH RECEIVES CURRENT FROM THE POWER PLANT AT MONTEREALE

$2\frac{1}{2}$ miles, with a fall of about 2 per cent. At two points, however, brick and concrete conduits carried over bridges were made necessary by the topography of the country. The water is received at the power station through a pipe 2 feet in diameter, the total length being 6230 feet. The total fall is 1148 feet. There is a large reservoir at St. Antonio, and the water may thus be maintained practically constant, re-

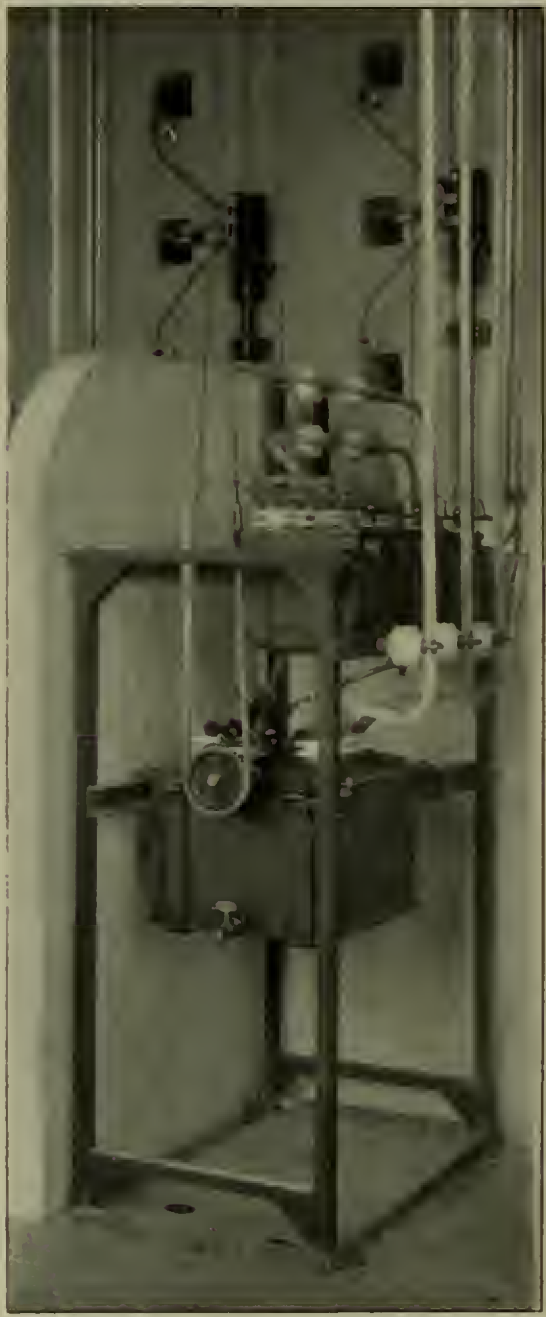


FIG. 6.—TRANSFORMER OIL SWITCHES AT THE VENICE SUB-STATION

gardless of the period of the year and the consumption of power.

Brick and stone are used in the construction of the power house, with foundations of concrete and with a tiled roof. An overhead travelling crane of ten tons capacity is provided for handling the heavy machinery.

An interesting Italian hydro-electric installation is that at Montereale, on the Cellina River, which has its source in the Carnic Alps, and is reported to deliver 1050 cubic feet a second at the dryest season. A reservoir, of a capacity of more than 11,700,000 cubic feet, and pro-

FIG. 7.—OIL SWITCHES AND TRANSFORMERS FOR SUPPLYING CURRENT TO SWITCHBOARD INSTRUMENTS IN THE PLANT AT MONTEREALE

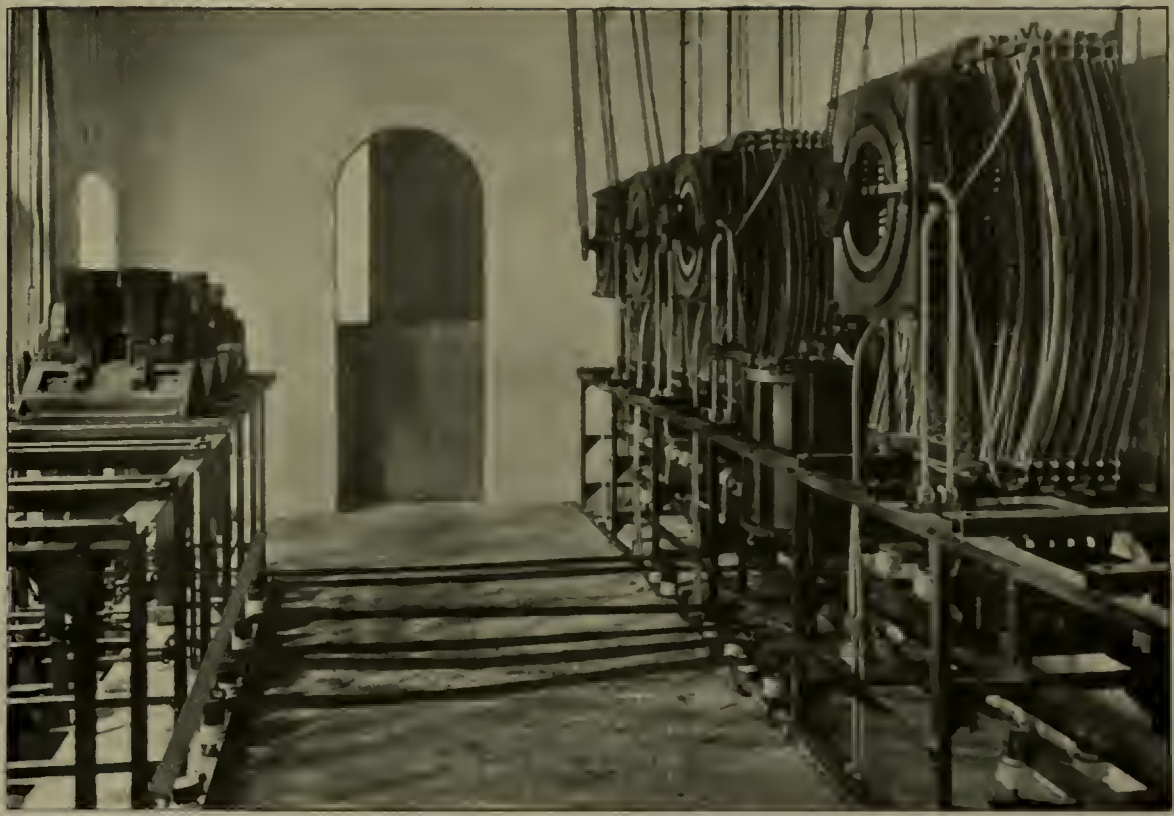


FIG. 8.—REGULATING RHEOSTATS IN THE CELLINA RIVER POWER PLANT AT MONTEREALE

vided with electrically operated sluice gates, keeps the water supply constant.

This plant contains six hydraulic turbines of the Francis type, each having a capacity of 2600 H. P., and driving by direct connection revolving-field alternators at a speed of 315 revolutions per minute. Two smaller turbines of 200 H. P. each are directly coupled to exciters. Another 200 H. P. turbine is direct connected to a direct-current exciter and also an alternator. The latter may be operated as a generator or used as a synchronous motor to drive the exciter. The alternators are of the revolving-field type, and generate current at 42 cycles and 4000 volts. The generators were built by Brown, Boveri & Co., of Baden, Switzerland, and the turbines by Rivera Mouneret & Co., of Milan Italy.

The switchboard in the power plant on the Cellina is installed in a gallery with cement stairways and floor, shown in Fig. 10. The high-tension apparatus is installed under the gallery, as shown through the large glass doorway in the foreground. Fig. 9 shows the transformers for raising the pressure from 4000 to 36,000 volts. These consist of five groups of three single-phase, 1000-KW. transformers of the oil-cooled type. They may be connected either in delta or in star. Four of the groups are in service, one being used as a reserve. A three-phase transformer is also provided for supplying light and power in the generating station.

Fig. 8 shows the regulating rheostats, which are installed under the gallery, the contact devices being moved from above by means of sprockets and chains. Fig. 7 shows

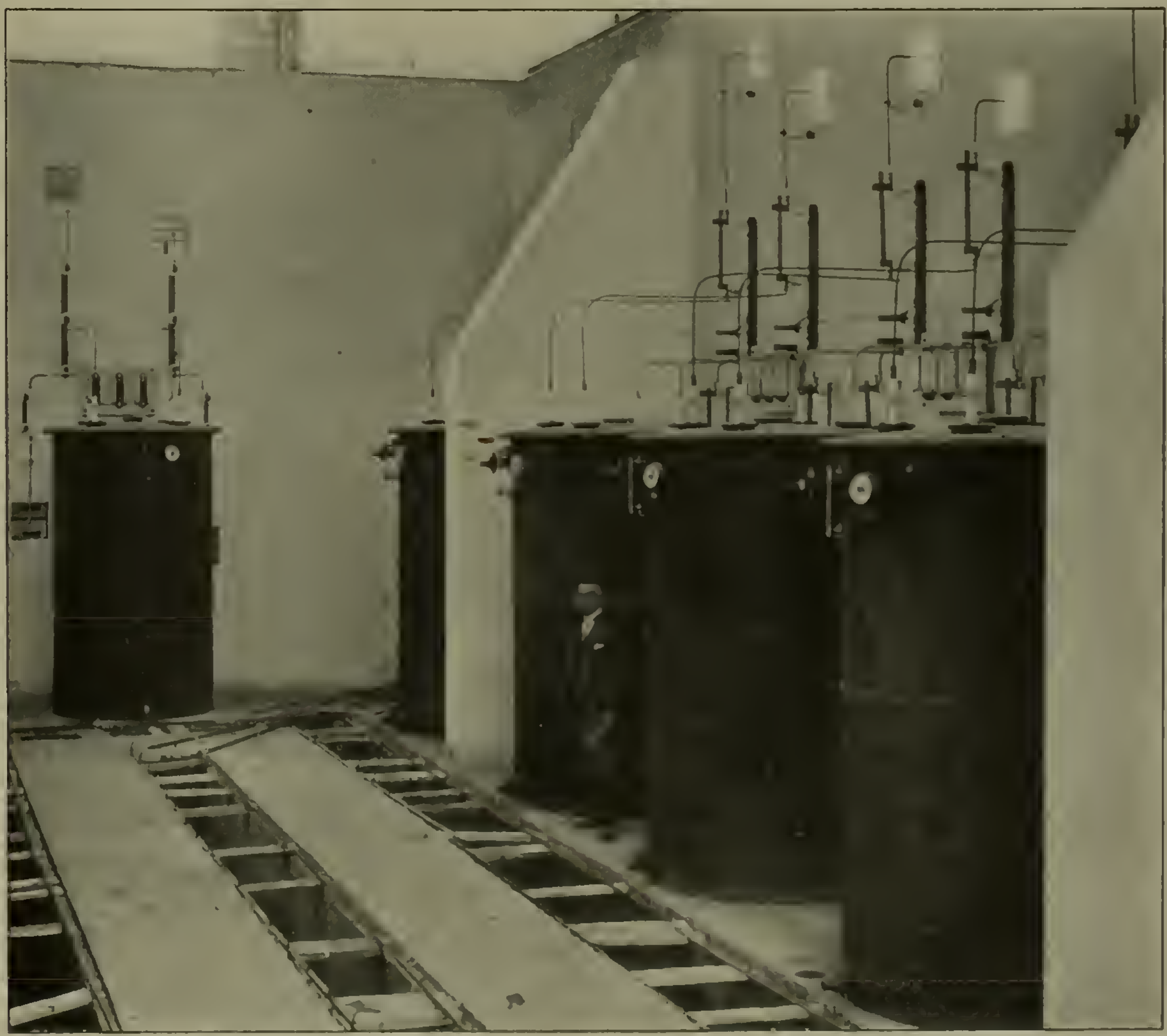


FIG. 9.—SINGLE-PHASE TRANSFORMERS AT THE CELLINA RIVER PLANT FOR RAISING THE PRESSURE FROM 4000 TO 36,000 VOLTS. FIVE GROUPS OF THREE SINGLE-PHASE TRANSFORMERS ARE INSTALLED

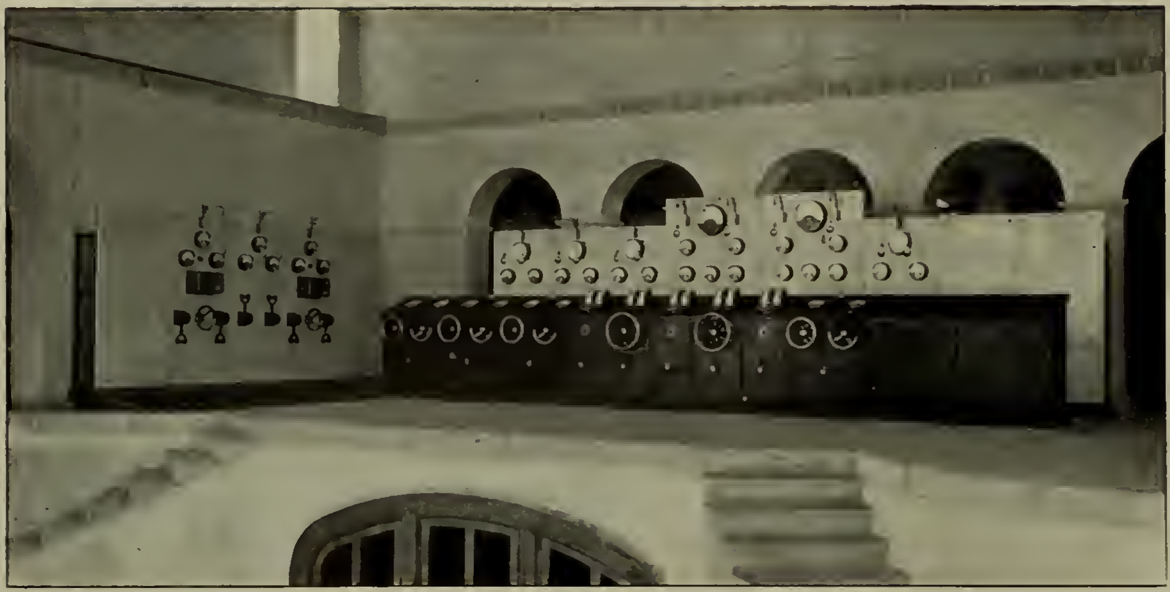


FIG. 10.—SWITCHBOARD AND GALLERY IN THE CELLINA RIVER PLANT

the arrangement of the switches in cells or concrete chambers, and also the fuses, insulators, and transformers for supplying current to the measuring instruments on the high-tension switchboard. Fig. 6 shows the transformer switches at the Venice sub-station.

From the power station to the sub-station at Venice is a distance of 56 miles, and over this extends four circuits of three conductors each, the twelve being mounted on double poles in a hexagon, as shown in Fig. 12, on this page.

Still another interesting Italian development is that of the Societe Franco-Suisse pour L'Industrie Electrique. The water supply is obtained from the Tusciano River, which has its source in the ravines south of the mountains in Salerne, and flows into the Mediterranean near Battipaglia. Current for light and power service is furnished to the industrial centres of Salerne, Torre Annunziata, Scafati and Nocera.

The power station is located near the village of Olevano, about $4\frac{1}{2}$ miles from Battipaglia, the water being conducted from the river by a canal $3\frac{1}{2}$ miles long with a fall of 187 feet in 1000. The capacity of this canal is 99,000 cubic feet a second. At the power station a penstock, 39 inches in diameter and 2250 feet long, carries the water to the wheels. The total head is 946 feet, the effective head being 913 feet. In the station there are five units of 1400 horse-power each and two units of 150 horse-power each, shown in Fig. 11. The smaller turbines drive exciter generators for supplying direct current to the field coils of the alternators. The turbines were constructed at Geneva, Switzerland, by Piccard, Pictet & Co.

Although the plant was designed

FIG. 12.—PART OF THE TRANSMISSION LINE FROM MONTEREALE TO VENICE. FOUR THREE-PHASE CIRCUITS ARE MOUNTED ON DOUBLE POLES

for a total capacity of 10,000 horse-power, the first equipment had an output of only 7000 horse-power. The unique construction of the hydraulic machines is shown in Figs. 13 and 14. The water enters at the side of the casing near the main shaft bearing and strikes the wheel buckets from within. The rims holding the buckets form heavy fly-wheels, which greatly aid in the regulation of the turbines. Each wheel is provided with an automatic regulator, shown in Fig. 13. The orifice supplying water to the wheel is variable in section and under perfect control of the regulating apparatus, which is of the Piccard relay type.

To each of the 1400-horse-power turbines is directly coupled a Westinghouse fly-wheel revolving-field alternator supplying a current of 3000 volts pressure. These generators are supplied with exciting current from eight-pole, direct-current machines driven at 700 revolutions a minute by 150-H. P. turbines similar to those illustrated.

For use on the high-tension transmission lines, the current is raised by means of step-up transformers from 3000 volts, at which the current is generated, to 30,000 volts, the pres-

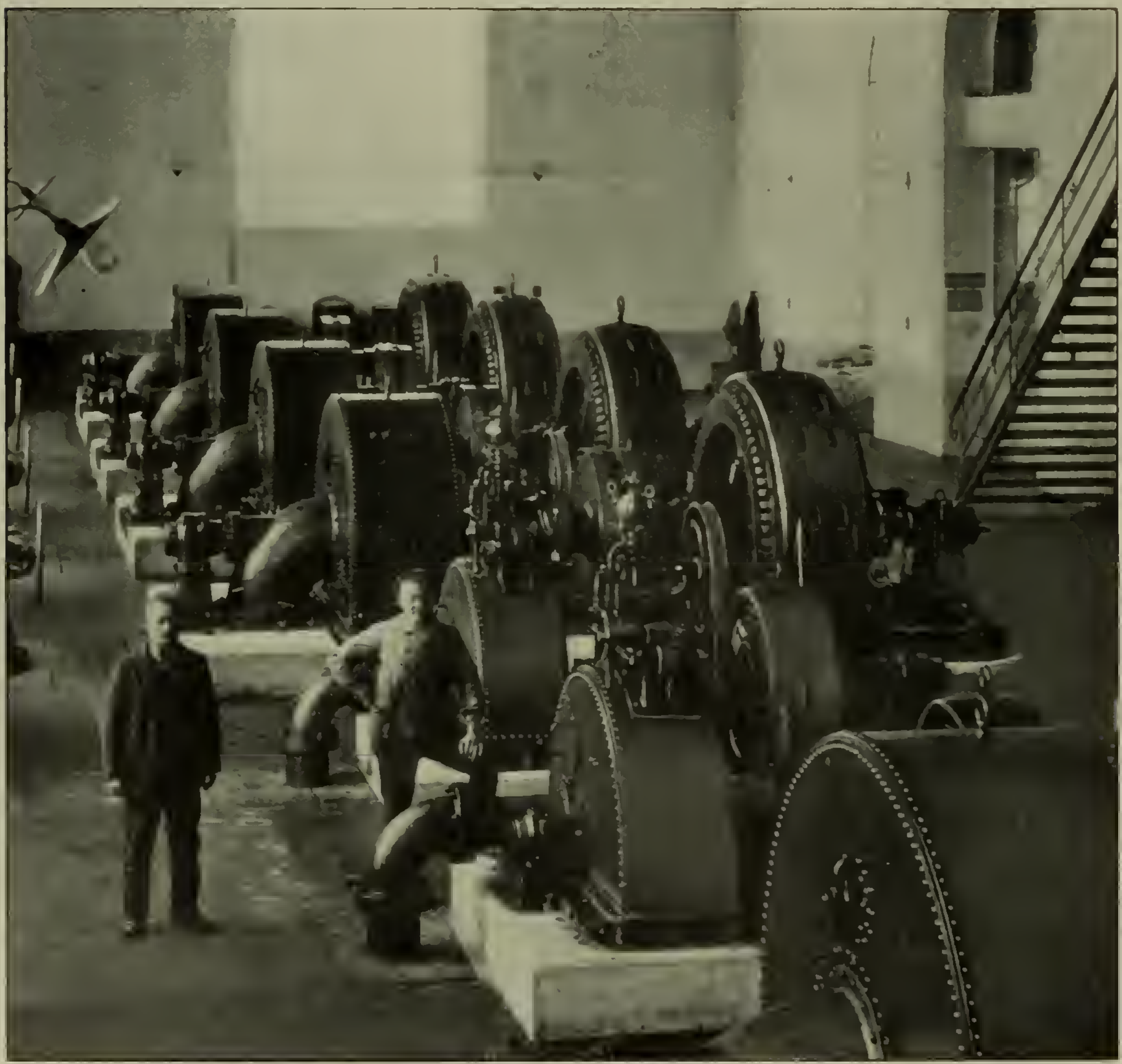
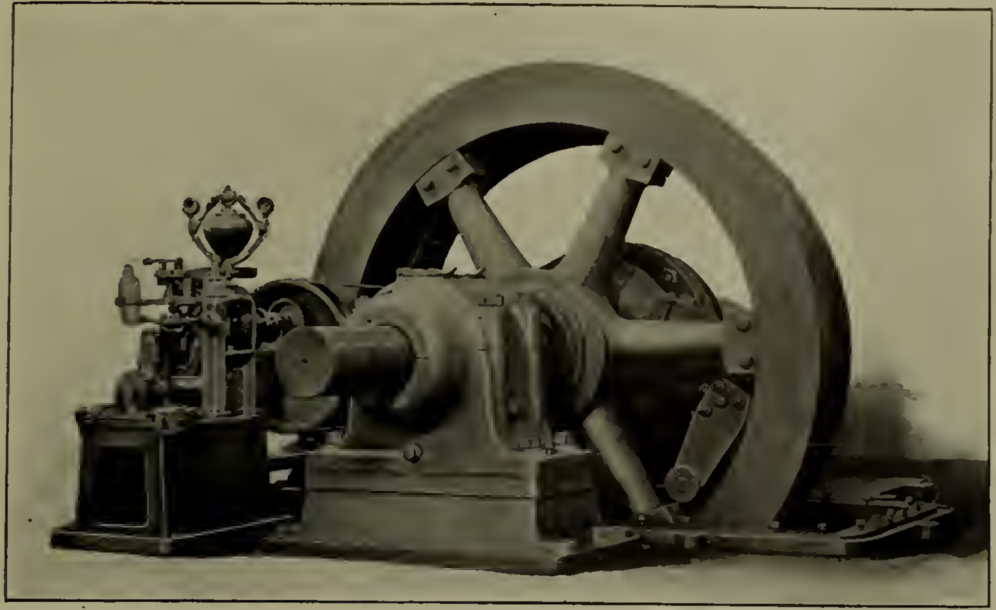
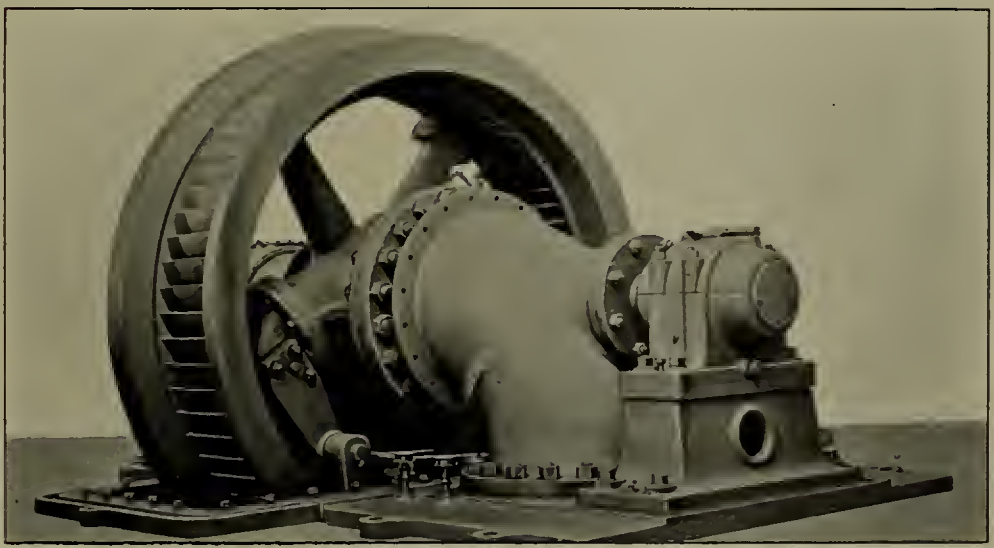


FIG. 11.—INTERIOR OF THE TUSCIANO RIVER PLANT IN ITALY, SHOWING FIVE 1400-H. P. UNITS AND TWO 150-H. P. EXCITER UNITS





FIGS. 13 AND 14.—ONE OF THE TURBINES INSTALLED IN THE TUSCIANO RIVER PLANT

sure used on the transmission line.

Another important hydro-electric plant in Northern Italy near the French border, which is operated by the Societé Franco-Suisse pour L'Industrie Electrique, is that shown in Fig. 16. Fig. 15 shows one of the turbines with the governor mounted on top. The turbines and governors were built by Piccard, Pictet & Co. As will be seen, the regulation is aided by means of a fly-wheel mounted between the turbines and the generator.

In Austria one of the recent developments is that at Innsbruck. Water is obtained from the River Sill, and is conducted to the power house by a canal 4½ miles long. One of the difficulties which had to be overcome was the presence of sand in the water. By the use of sand traps, however, the water was freed from this very undesirable content. The fall from the dam and reservoir to the power house is about 617 feet. Fig. 18 is a section of one of the wheels and governor. The way in which the size of the jet is changed is clearly shown. Current is generated at 10,000 volts.

There are many water-powers in Norway remaining undeveloped, and there is great activity at the present time among electrical and mechanical engineers of the country, designing and constructing hydro-electric power stations for the transmission of electrical energy to neighbouring cities, and also for use in electrochemical industries. The "Norske Kvaelscof Companie" have recently constructed a saltpetre factory at Notodden, in the Hittedal, in which electric energy is employed for the manufacture of nitrate of lime, the production of the Norwegian saltpetre calling for nothing save the electric furnace, electric power, limestone, air and water, all of which are available at low cost. The nitrogen is obtained from the air, by the arc process of Birkeland and Eyde. The cost of electrical energy at this plant on the Tinnfos, where 6000 H. P. is developed, is said to be $8.50 per kilowatt-year.

The company will shortly enlarge its plant and utilize another waterfall three miles up the gorge of the Tinnelf, having a total capacity of nearly 30,000 H. P. This company also is planning to utilize three other waterfalls, one of which has a capacity of 25,000 H. P., at Boilfos, near Arendal, while a second plant, of 40,000 H. P., will be installed at Wanmma, on the River Glomen, on the Swedish border. A still larger fall is to be utilized at Telemarken.

It is estimated that here a maxi-

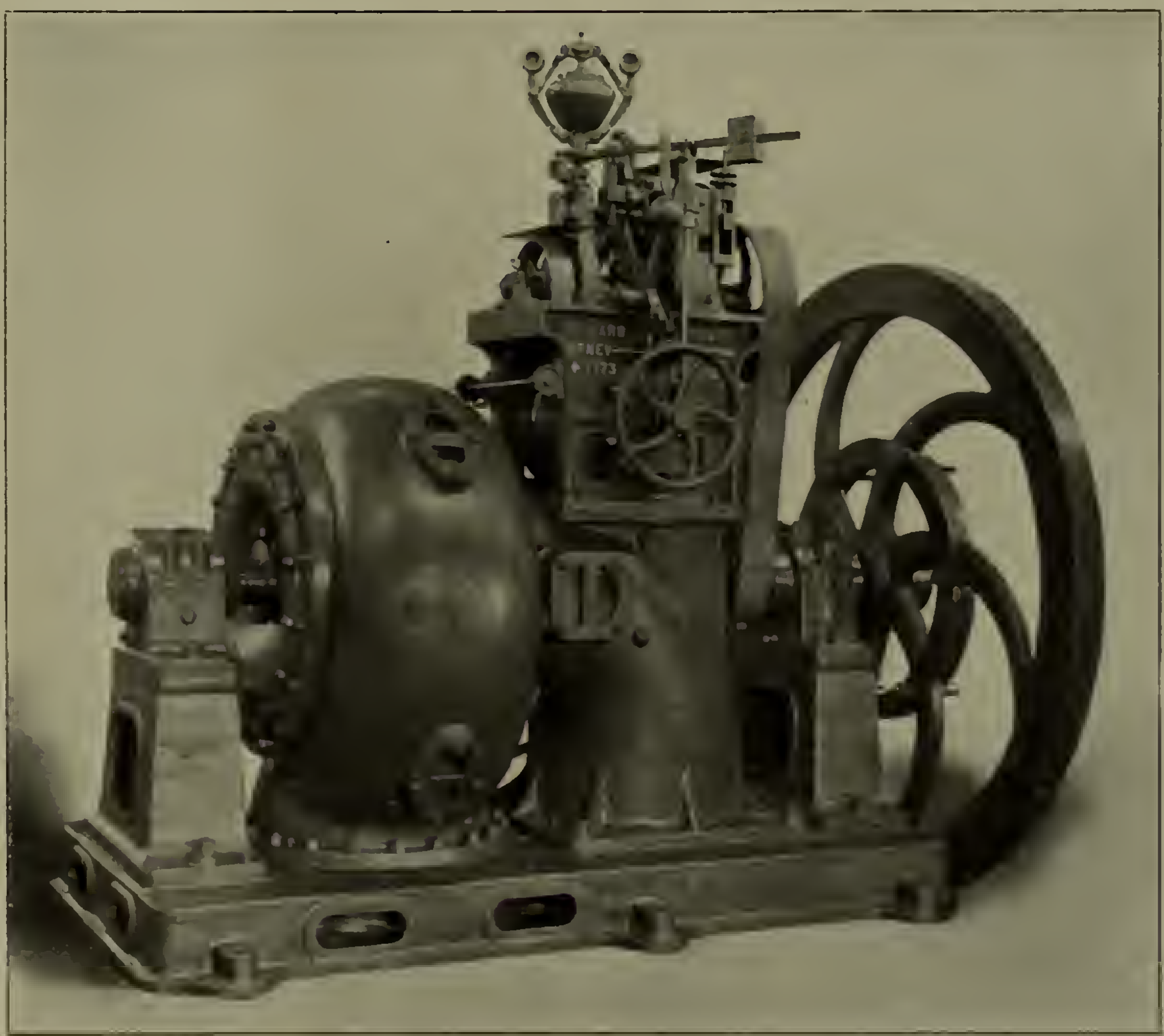


FIG. 15.—ONE OF THE TURBINES USED IN AN ITALIAN HYDRO-ELECTRIC PLANT

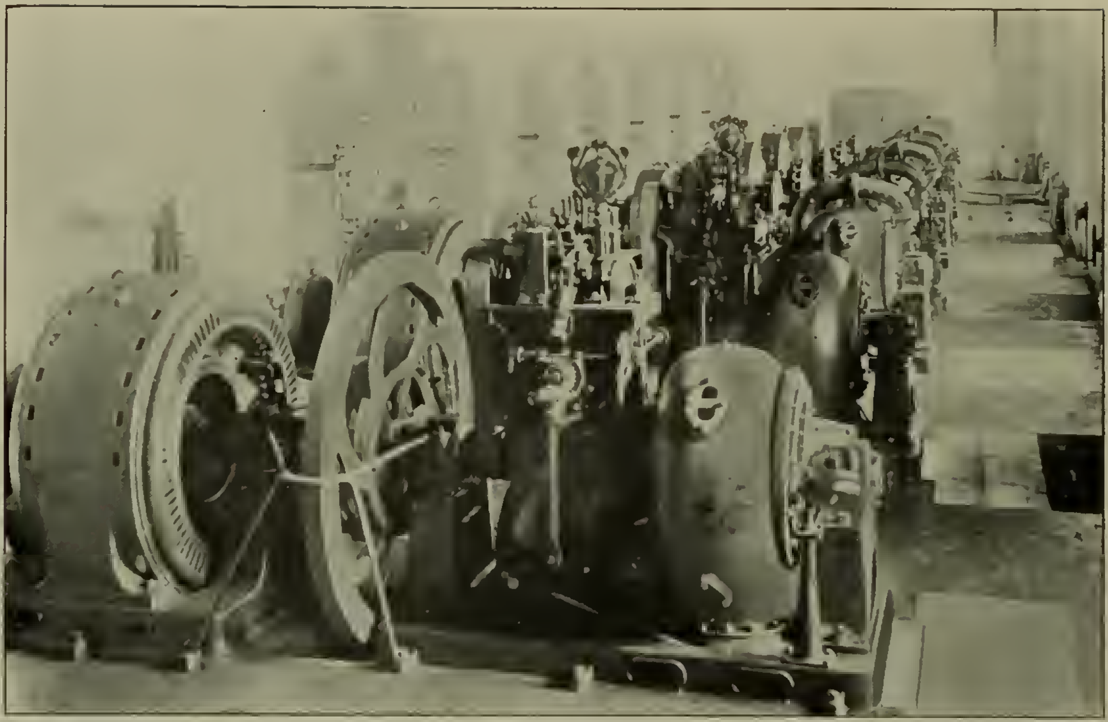


FIG. 16.—INTERIOR OF AN ITALIAN HYDRO-ELECTRIC PLANT IN NORTHERN ITALY

mum of about 300,000 H. P. can be developed, with a minimum of about 250,000 horse-power. It is said that nowhere else in Europe is there a water supply which presents so favourable a field for the enterprising electrical and mechanical engineer.

The accompanying illustrations show a thoroughly up-to-date and modern electrical power generating and transmission plant installed on the Glommen near Kykkeelsrud, in Southeastern Norway. Fig. 19 shows the neat construction of the power house of the "Elektrizitats Werk am Glommen," the tail race, and the intake canal. Fig. 20 shows the interior of this station, with its vertical generators for power generation as well as excitation, the neat switchboard gallery with its marble panels and high-tension rooms below and back of the switchboard, and equipped with oil switches, transformers and high-tension bus-bars, as shown in Figs. 21 and 22.

The Glommen power plant is equipped with two vertical turbines of 3000 H. P. capacity directly coupled to two 3-phase dynamos of 2500-KW. capacity, and also with three vertical turbines of 280 H. P., each directly coupled to direct-current dynamos used as exciters and noted in the foreground of Fig. 20. The main turbines were constructed at Zurich, Switzerland, by Escher, Wyss & Co., and the exciter turbines by J. M. Doith, of Heifdenheim.

FIG. 17.—VIEW OF THE HYDRO-ELECTRIC PLANT AT INNSBRUCK, IN AUSTRIA

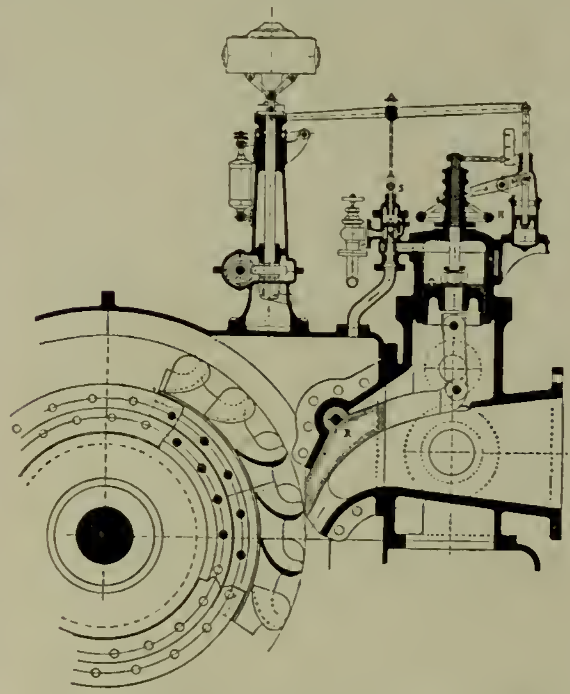


FIG. 18.—SECTION OF A WHEEL AND GOVERNOR IN THE INNSBRUCK PLANT

The power house was designed so that the present building will hold two more units of 3000 H. P. capacity, while provision has been made for an extension to the south capable of holding three turbines and generators of 5000 H. P. each. To the north provision has been made for five turbines, also of 5000 H. P., making the total output of the plant nearly 50,000 H. P.

The water delivered from the Glommen has a fall of 62 feet, and

FIG. 19.—A HYDRO-ELECTRIC PLANT ON THE GLOMMEN RIVER, IN SOUTHEASTERN NORWAY

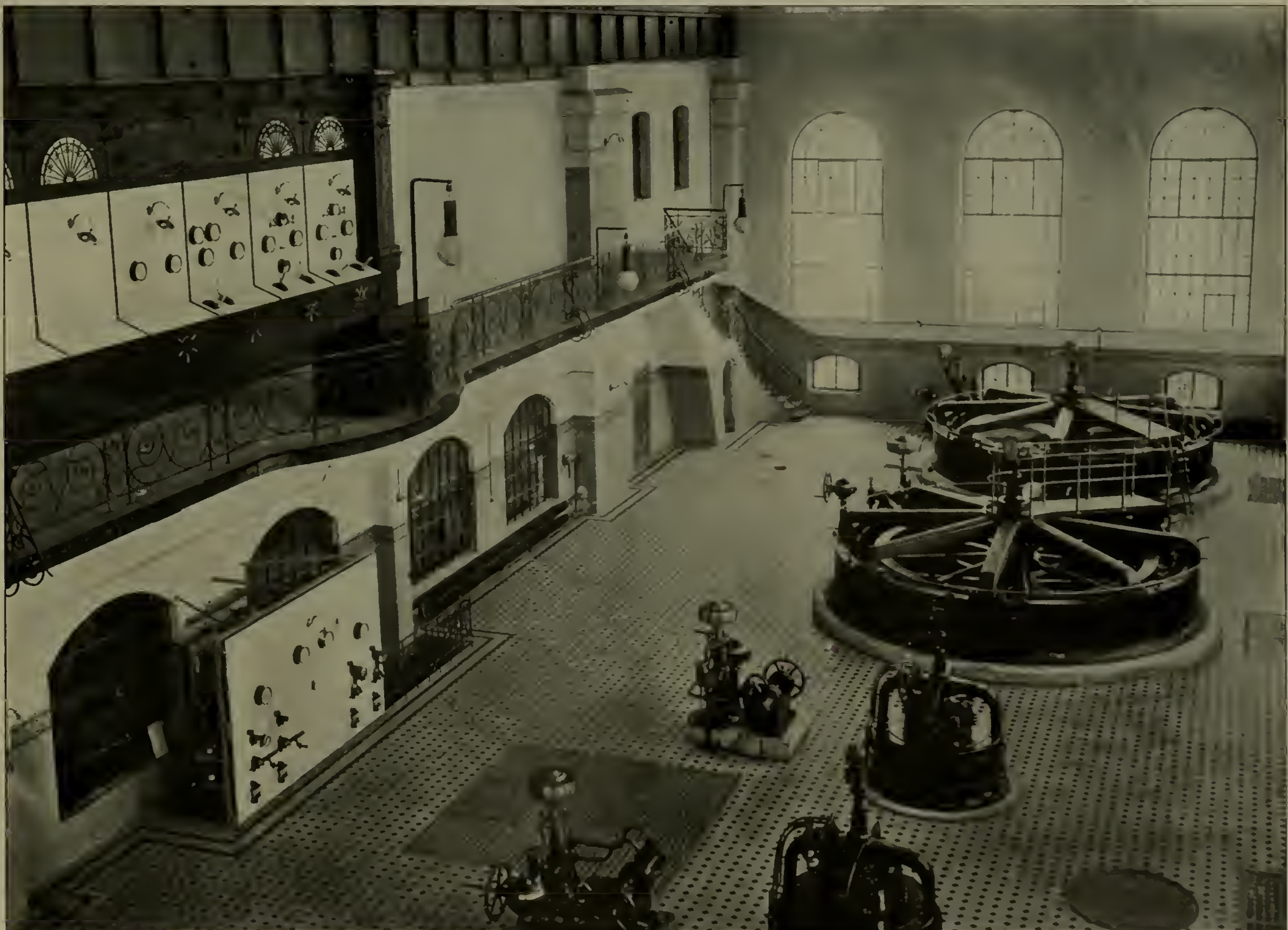


FIG. 20.—INTERIOR OF THE GLOMMEN RIVER PLANT, SHOWING TWO 3000-H. P. UNITS AND TWO OF THE THREE 280-H. P. EXCITER UNITS

FIG. 21.—TRANSFORMERS IN THE GLOMMEN RIVER POWER PLANT. CURRENT IS GENERATED AT 5000 VOLTS AND RAISED TO 20,000 VOLTS

the present supply of water possible with the hydraulic equipment is 9200 cubic feet of water per second.

The 300-H. P. turbines at present in operation are directly coupled to generators of the revolving-field type, constructed by the Siemens-Schukert Werke, of Berlin, Germany. These alternating-current generators are 40-pole machines, and supply current at a frequency of 50 cycles. The exciter dynamos each have a capacity of 181.7 KW.

The current is transmitted by long-distance lines at a pressure of 20,000 volts, being generated at 5000 volts and raised to 20,000 volts by oil transformers, each having a capacity of 950 KW.

The current is transmitted from this central power station by five 3-phase lines, four to the north and one to the south. The longest transmission line to the north is slightly over 100 miles in length. Leaving the power house in this direction are two rows of steel poles, with two circuits of three wires on each pole line. The longest transmission line from the power house runs 139 miles to the Slemmestad sub-station.

On the various transmission lines there are seven sub-stations equipped with step-down transformers of the oil type, which lower the pressure from 20,000 volts to 5000 volts, at which pressure the current is supplied to smaller transformer stations, where the current is again reduced in pressure to 220 volts for light and power service.

In discussing the progress in electrometallurgy in 1905, J. B. C. Kershaw says, in "The Engineering and Mining Journal," that the year 1905 was marked by a striking development in the electrolytic-refining industry in America, many of the refineries having been remodeled and enlarged. The aggregate production of the American refineries is stated to have doubled during the last six years; and, according to the published figures, the capacity of the electrolytic refineries is now nearly equal to the whole of the annual output of raw copper. In Europe the position as regards the refining industry is stationary. A new process for producing moulded articles in copper was introduced during 1905. These are moulded in clay, coated with black lead, and then coated with copper by electro-deposition. The results are said to be good, and the cost of the finshed articles is lower than by the older methods.

FIG. 22.—OIL SWITCHES IN THE GLOMMEN RIVER PLANT

Proposed Trackless Trolley for Detroit

A PROPOSED trackless trolley road in Detroit was described by A. S. Hatch at the recent meeting of the International Association of Municipal Electricans. The line will be run to Belle Isle Park, an island $2\frac{1}{2}$ miles long and varying from $\frac{1}{2}$ mile to 1 mile in width. It is reached only by boat or by horse-drawn vehicle over a bridge. The present means of conveyance are inadequate for the large crowds, numbering at times 150,000.

In seeking for a new means of conveyance, the conditions to be met were that the system must be capable of handling at least 5000 people an hour, at a speed of six miles an hour and must be free from tracks on the grade of the roadway. Where vehicles are run on the grade of the roadway, they must be free to go in any part of the road with other vehicles. The maximum weight allowed on any span of the bridge is ten tons, so that any increased amount would require new bridge construction.

The following systems were considered:—Trackless trolley, automobile plate roads, elevated roads, moving sidewalk, ferry, and horse-drawn vehicles. Automobile plate roads are those in which a locomotive travels on a roadbed of iron plates, drawing several wagons behind.

After considering all these systems, the choice narrowed down to the plate road, the trackless trolley, and electric and gasoline automobiles. It was found that the plate road could be constructed for less than the other two systems, but the greatest objection to it was that the longest trains would be in service during the most crowded hours when the largest number of children are on the island, making it the most dangerous system, since it could not be kept under control as well as the individual cars.

In considering electric automobiles, it was found that the weight of the batteries would prohibit the use of these vehicles. The choice therefore narrowed down to the trackless trolley or gasoline automobiles. A comparison of the initial cost of these systems showed that the latter had the advantage, as follows:—

	Automobile	Trolley
Cars	$32,000	$24,000
Line construction	......	8,625
Buildings, roadway, shop	7,500	7,500
Plant and shop tools	2,000	7,000
Loading and unloading stations	4,800	4,800
	$46,300	$51,925

The operating costs, however, show a decided advantage in favour of the trolley, as given in the table below.

It is thus seen that with the trackless trolley the cost one way per car would be 22 cents, or an average of 1.1 cents per passage, if only one-half the capacity of the car, or 20 passengers, is taken. At no time should the average be less than that. At a fare of 2 cents per trip, with a load of 40 passengers, the gross receipts per car would be $1.60 and the net receipts $1.16. In the rush hours, however, the car could be loaded to about double the normal capacity, making the net receipts $2.78 per car.

	Automobile	Trolley
Interest, 4 per cent., depreciation 5 per cent	$4,167.00	$4,673.25
Supervision	7,000.00	7,000.00
Fixed costs	$11,167.00	$11,673.25
Operating costs at round trip rates	22,575.00	11,610.00
Total on above assumption	$33,742.00	$23,283.25

ITEMIZED OPERATING COSTS

	Automobile	Trolley
Supervision as above (fixed cost)	$11,167.00	$11,673.25
Maintenance, 12½ cents per trip	8,062.50	8,062.50
Maintenance, motors (8½ cents)	5,482.50	....
Maintenance, motors (33⅓ per cent. cost)	....	1,600.00
Station labour, 2 men	....	2,160.00
Station, supplies	....	360.00
Running, 40 H. P. ¼ hour per trip, gasoline 12½ cents, oil and waste 3½ cents; total, 16 cents	10,320.00	....
Running, 9 K. W. at car, 12 at barn; current 5.62 cents, oil 1.38 cents	....	4,515.00
Totals	$35,032.00	$28,370.75
Average cost per round trip	.53	.41

The inadequate system as now in use cost for the year 1905 as much as the others would.

The cost of care of horses and repair of phaetons was	$24,442.92
Supervision, interest, depreciation, at least	12,000.00
Total on same basis as above	$36,442.92

Speculations Regarding Radium

EXTRAVAGANT statements regarding radium are decried by Lord Kelvin and Prof. H. E. Armstrong in letters to the "Times," of London. At the recent meeting of the British Association for the Advancement of Science, Prof. Soddy discussed the possible transmutation of the elements, and made the statement that the production of helium from radium has established the fact of the gradual evolution of one element into others.

Regarding this, Lord Kelvin says:—

"I wish to remark that an isolated experimental discovery by Sir William Ramsay and Prof. Soddy, brilliantly interesting as it is, and solidly instructive as it is toward the theory of radium, suggests nothing more toward any modification of the atomic doctrine, proposed some 2500 years ago by Democritus and universally adopted by chemists and other philosophers in the nineteenth century, than does Ramsay's original discovery of helium as an emanation from the mineral clevite. The obvious conclusion from the two discoveries is that clevite and radium both contain helium.

"I cannot refer, thus publicly, to discussions on radium in the meeting of the British Association, which commenced last Wednesday in York, without protesting against the hypothesis that the heat of the sun or earth or other bodies in the universe is due to radium. I believe it is mainly due to gravitation, and I believe that the experimental results on which the radium hypothesis has been built give no foundation on which it can rest."

In his letter, Prof. Armstrong says that the thanks of the public are due to Lord Kelvin for his timely and outspoken protest against the conclusion being drawn, from the evidence at present before us, that it is proved that there is a "gradual evolution of one element into others." No one has yet handled radium in such quantity or in such manner that we can say what it is precisely.

"That helium can be obtained from radium appears to be proved," he writes, "but no proof has yet been given that it is not merely contained in it. As I remarked at York last week, physicists are strangely innocent workers; formulæ and fashion appear to exercise an all-potent influence over them.

"There was a time when the expression 'scientific caution' meant the highest degree of caution, and it was supposed to be the attribute of workers in science. Workers in the radium school appear to have cast caution to the winds and to have substituted pure imagination for it. Among ourselves we should always be at liberty to postulate the most crack-brained of hypotheses, to dream the wildest of dreams, as a means of guiding inquiry; but we should not court popularity on such a basis. By so doing we lose all claim to guide public opinion."

The Need of Cotton in the Use of Electricity in Mines

IN his annual report for 1905, George Harrison, chief mine inspector of Ohio, says that electricity as an element of power in the production of coal is not only necessary from a standpoint of competition, but that its use in every legitimate way in the advancement of civilization is justified. It is, however, highly essential that the greatest caution be exercised in its application so as to avoid loss of life or injury to persons coming in contact with it.

Many of the largest mines in Ohio now using electricity were formerly pick mines, and have been developed into electric-mining-machine mines beyond a territory worked out on the old pick-mining system. In many cases there is but one narrow entry that penetrates and extends through the old worked-out territory to the new development, which, of necessity, must be used as a motor haulway and travelling way as well, for employees who are employed therein.

In this entry it is also necessary to have the motor wire and the positive and negative wires on which to conduct the electricity to operate the mining machines, etc. This is not all. We often find a line or two of water or steam pipes strung along one side or the other of the track. Consider a space probably 8 feet wide, and 4½ or 5 feet high, containing all this paraphernalia and a trip of mine cars propelled by an electric motor at a speed of 10 miles an hour, and it is easy to conceive how difficult it is for the miners to travel in and out without rubbing against a live wire or being caught by a passing trip of cars.

This condition of things, in some instances, cannot well be avoided, and, if any radical changes were enforced, it would mean the closing down or abandonment of the mine, but there are a number of cases where openings could be provided at the head of the workings at nominal cost, and used for the purpose of miners travelling in and out of the mine free from dangers incident to travelling in the main haulway.

There were six fatal acidents during the year resulting from contact with electric wires in mines in Ohio, all the victims being foreign-speaking men. This may not seem a very large number of fatal accidents considering the amount of coal produced and handled by electricity; but if proper care and foresight are used in the construction of wires, which can very easily be done, especially in the opening of new mines, Mr. Harrison is of the opinion that fatal accidents from this cause can almost entirely be eliminated. It is also very noticeable that, with few exceptions, the fatal acidents from coming in contact with electricity is where a high power of 500 or 550 volts is carried, which also seems unnecessary, as it is fatal to those whose misfortune it is to come in contact with the wires.

Some manufacturers of high-power electric machinery and mine operators who desire to use such may take exception to the Department of Mines raising the question of limited voltage; but we feel, says Mr. Harrison, that it is but fair to the 95 per cent. of mine operators in the State to say that they are successfully operating their mines with a power not to exceed 250 volts, which in few cases proves fatal where persons stumble against the wire, and those operators ought not to be charged in common for the loss of life with those who use an unnecessary and excessively dangerous power, and under whose operations these accidents almost exclusively occur.

A recent annual report of the Boston Wire Department shows that there are used in the city 971,711 incandescent lamps, 15,271 arc lamps, and 13,724 motors of a total horse-power of 192,493. The total rated horse-power of the engines in the power plants is 142,931. The Boston Elevated Railway Company has an engine capacity of 54,450 H. P., with 153,860 H. P. in motors. The Edison Electric Illuminating Company has an engine capacity of 44,840, with 28,030 in motors.

The new Marconi station now being built at Clifden, County Galway, will be the largest of its kind on the other side of the Atlantic. The work was begun last November, and will not be completed until the end of the year. The station is intended for the transmission and reception of messages from America.

Electricity in a Modern Market

By H. S. KNOWLTON

AN ELECTRICALLY DRIVEN BRINE PUMP IN THE MANHATTAN MARKET IN CAMBRIDGE, MASS. AT THE RIGHT IS A MOTOR FOR DRIVING A GENERATOR SUPPLYING CURRENT FOR LIGHTING. THE LATTER ARRANGEMENT IS TO BRING THE POWER LOAD UP IN ORDER TO OBTAIN A LOW RATE

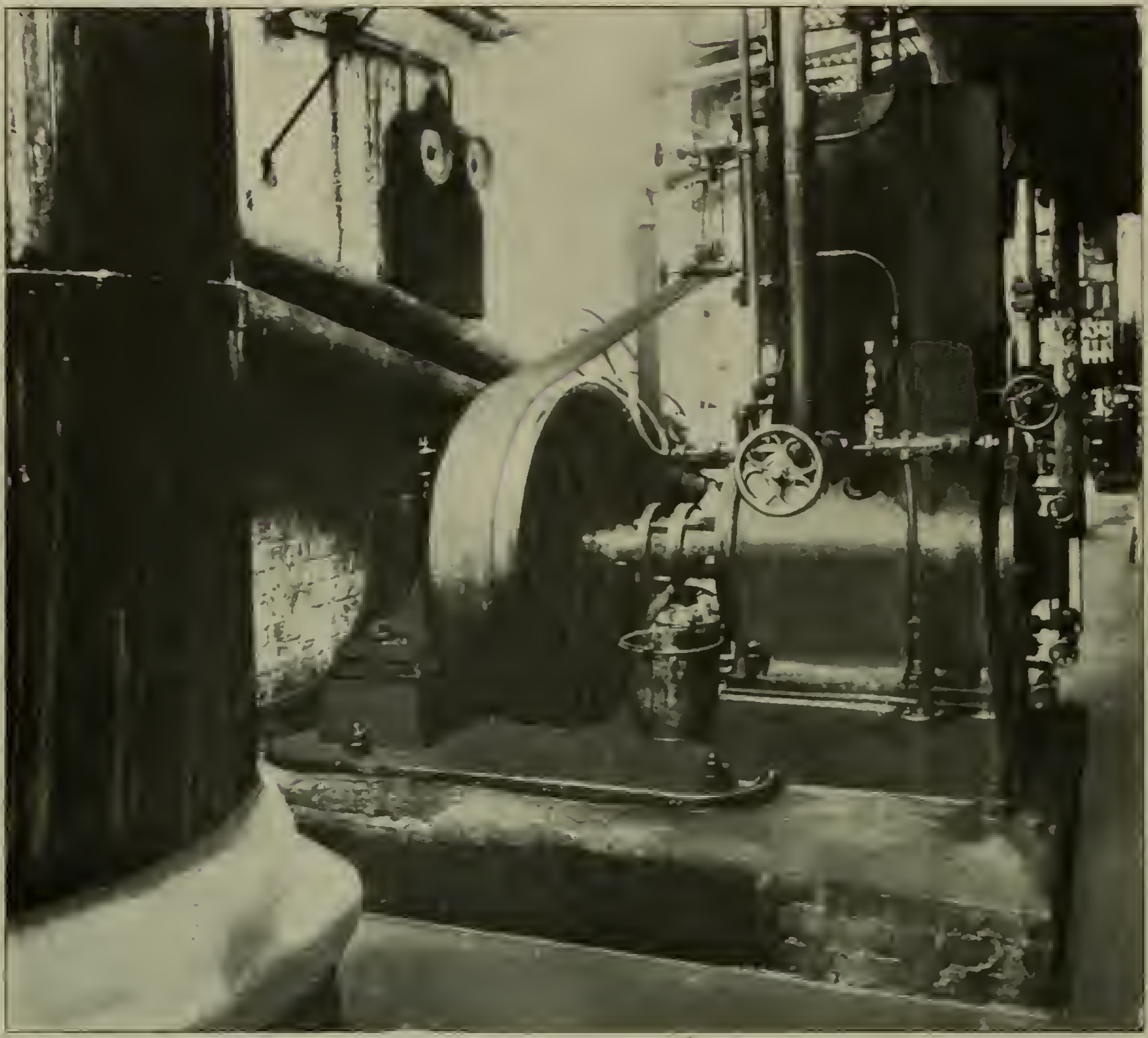
AMONG the recent applications of electricity to the purposes of retail trade, the market installation offers an attractive field for the securing of operating economies. Comparatively few markets are yet equipped with an extensive variety of electrical apparatus, and in many cases the only use of electricity in such establishments is for illumination. The cleanliness of this method is a strong point in its favour, in all houses where foodstuffs are handled, and the day has passed when anything but the most sanitary appliances are acceptable in a modern market. Few owners of markets and groceries realize the uses to which electricity can be turned in the purveying business, both for power and lighting.

A MOTOR DRIVING A MEAT CHOPPER

A notable installation of electrical machinery is to be found in the "Manhattan Market," located on Massachusetts Avenue near Central Square, in the City of Cambridge, Mass. This establishment is the largest market in Cambridge, and aside from the usual meat, fish, and delicatessen departments, the company does an extensive business in the supply of dairy products, fruit, groceries, canned goods and kitchen supplies. A public lunch counter is also found within the premises. The establishment employs one hundred persons, and yet it contains every labour-saving appliance which experience has suggested as valuable.

Current for power and lighting is supplied in three services by the Cambridge Electric Light Company. There are eight motors in the establishment, 52 Nernst lamps, and a considerable number of 16-candle-power incandescents, besides a number of fan motors of the ceiling and desk types. The central station service consists of a 550-volt, 3-phase, 60-cycle circuit, a 220-volt, 3-wire alternating circuit, and a 52-volt direct-current circuit. The Nernst lamps are of the six-glower style with the exception of one three-glower lamp, and are operated upon the 220-volt line. All the motors except one are operated by the 550-volt three-phase supply. The 52-volt direct-current circuit operates a single motor and some incandescent lamps, principally in the basement, as a supplement to a local 52-volt circuit derived from a generator on the premises.

The 550-volt motors are all of the induction type, wound for 60-cycle current. There are two 15-H.P. motors, one of 7.5 H. P., one of 2 H.P., two of 1 H.P., and one ½-H. P. motor. The direct-current motor is rated at 1.5 H. P. The motors of 2



AN ELECTRICALLY DRIVEN AMMONIA COMPRESSOR IN THE MANHATTAN MARKET IN CAMBRIDGE, MASS. THE EXPANSION TANK IS SHOWN AT THE LEFT

H. P. or less are started by throwing them directly upon the line without any resistance or inductance between the line and the motors. All are Westinghouse machines except the direct-current outfit, built by the Holtzer-Cabot Electric Co., of Boston.

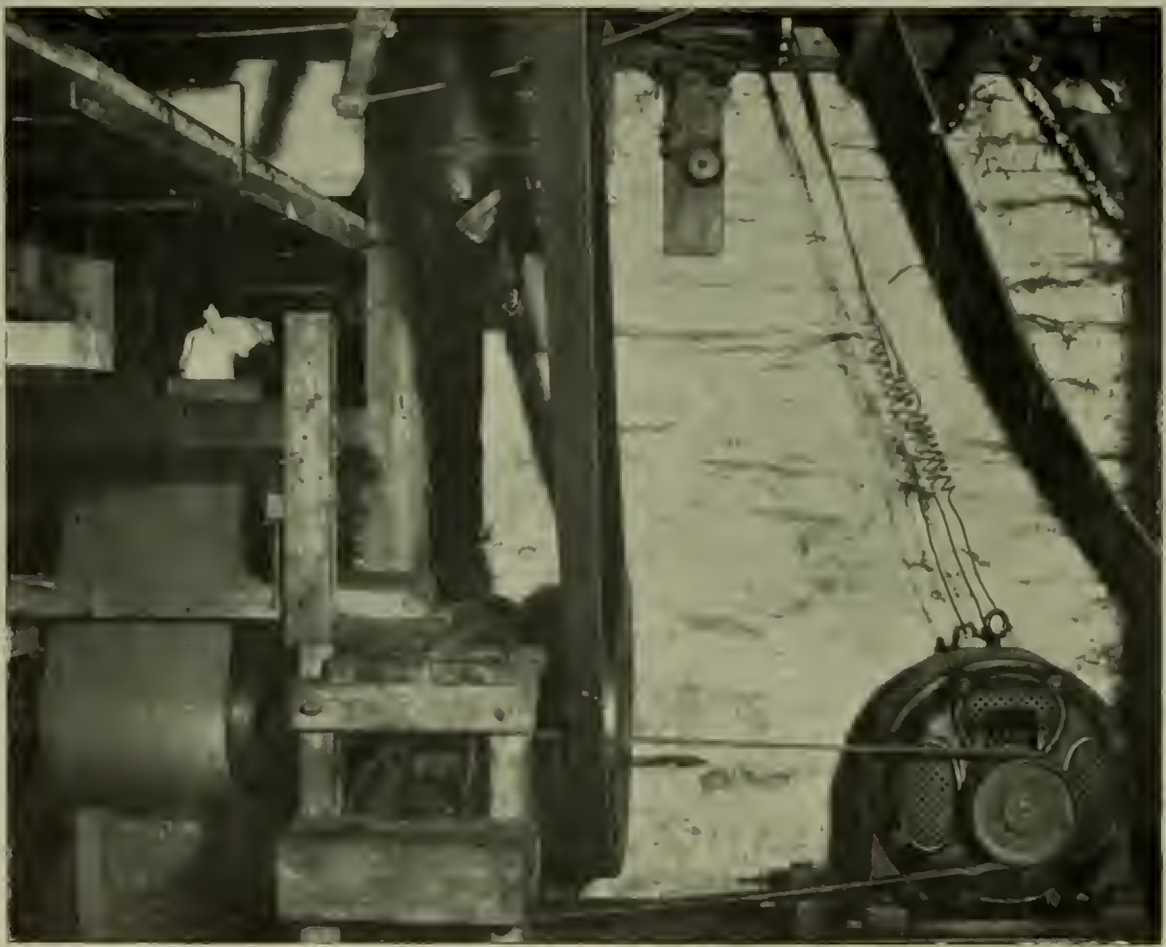
Refrigeration is probably the most important mechanical problem to be solved in the modern market, although the transportation of orders and supplies is in no sense of secondary consequence. The Manhattan Market is equipped with a $7\frac{1}{2}$-ton ice machine of the brine circulating type, made by the York Manufacturing Company, of York, Pa. It is driven by a 15-H. P. motor, together with a Deane triplex vertical brine pump which has a capacity of 90 gallons per minute.

Short belt transmissions connect the motor with the brine pump and the compressor. The latter machine is of the vertical two-cylinder, double-acting crank-case type. Ammonia is the refrigerating medium used, and by its compression, liquefaction and expansion it absorbs the heat from the brine, which is then circulated around the plant through the cooling coils.

Three distinct and separate cycles are present in the apparatus: The ammonia cycle begins at the expansion coils, where the ammonia gas absorbs the heat from the returned brine. The ammonia gas is drawn into the compressor, and forced out, highly compressed, to the condenser. As the ammonia gas passes through the condenser tubes, which are surrounded by cold, flowing water, it condenses to a liquid, and is forced around the system to the expansion valve at the entrance of the cooler. Passing into the cooler, the liquid ammonia vaporizes, and in so doing absorbs heat from the returned brine, completing the cycle.

The second cycle is that of the brine, which is pumped around the system through the cooler, pump and refrigerating coils in various parts of the plant and back to the cooler in a closed loop. The cold brine absorbs heat from surrounding objects in the refrigerating chambers, and yields it to the expanding ammonia in the cooler. The third cycle is that of the condensing water, which enters the condenser cool and leaves it freighted with the heat of the compressed and liquefied ammonia. The operation of each cycle is continuous and the plant operates twenty-four hours a day.

The economy of this plant was cited by W. R. Eaton of the Cambridge Electric Light Company at the July meeting of the New England Association of Electric Lighting Engineers. The rooms cooled are: Meat refrigerator, 45 feet long, 22 feet wide and 17 feet high, temperature 35 degrees Fahrenheit; freezing room, 12 feet by 10 feet, 20 degrees; butter and cheese room, 16 feet by 16 feet, 37 degrees; vegetable room, 14 feet by 12 feet, 40 degrees; fish room, 10 feet by 10 feet, 45 degrees. Last year the cost of ice to this market was $2.50 per ton; this year it is



A MOTOR DRIVING A PARCELS CONVEYOR, WHICH TAKES PARCELS FROM SALESROOMS TO ASSORTING SECTION PRIOR TO SHIPMENT. THIS MOTOR ALSO DRIVES A BARREL HOIST

$3. The ice expense in 1905 amounted to $11.44 per day, while the cooling of the meat refrigerating room alone cost $5.72 per day. This year, with electric power at 2.5 cents per kilowatt-hour, the cost of operating the refrigerating plant is $4.02 per twenty-four hours, which means a saving of over $2600 per year at last year's ice charge.

The refrigerating coils are also applied to the meat display cases, instead of ice being used in the old-fashioned way. Cuts of meat are kept dry by the new method, and they remain in good condition much longer, exposed in a glass case with the electrically refrigerated coils below. The main meat refrigerator contains 1700 feet of 1-inch pipe, laid up in cooling coils. Small fan motors are used to circulate the air in the rooms to be cooled, and the ice boxes are electrically lighted.

One of the 15-H. P. motors, running at 1120 revolutions per minute, is belted to a 52-volt, 125 ampere, direct-current generator which operates the circuit of basement lights and a coffee mill belted through the floor to the 1½-H. P. direct-current motor previously mentioned. The coffee mill makes 400 revolutions per minute, and the motor 1000 revolutions per minute. The suspension of the latter from the basement ceiling enables the coffee mill to be compactly driven, without the occupation of valuable counter space by the motor. The basement lighting consists of sixty-five 52-volt, 16-candle-power lamps. This arrangement was employed to bring the total power load of the market to the proper point for a 2½-cent rate per kilowatt-hour.

Separate meters are installed on the Nernst lamp, 110-volt circuit, the 52-volt circuit and the 550-volt power lines. At night when the load is light, the direct-current generator is shut down and the basement lighted by the Cambridge company through a double-throw, double-pole switch which transfers the load.

An important feature of the market installation is a system of parcel and stock conveyors which facilitates the transaction of business to a remarkable degree. These conveyors are motor driven, and carry parcels from the counters to a checking desk and from the latter to the assorting room in the basement, where all outgoing orders are made up prior to delivery by the teams. After the orders are made up they are sent by a conveyor to the first floor, where the shipping department delivers them to the wagons.

Each conveyor is a continuous belt, and all empty parcel boxes are returned automatically to the sender. All the belt conveyors are 17 inches wide. The conveyor which collects orders on the ground floor delivers them to the basement and returns the empty boxes, is operated by a 7½-H. P. motor through a worm gearing. By means of a countershaft, this motor also drives a tramway elevator of the link-belt type, which is used to convey heavy articles from the receiving department to the street floor. This hoist has a run of 18 feet, is specially fitted with lugs to handle barrels, and has a capacity of 600 pounds. It can be started or stopped at any point of the belt travel. Goods are handled from the shipping department to the first floor by a belt of about 100 pounds capacity, driven by a 1-H. P. motor.

The main ice chest, or meat room, is ventilated by a continuously operated 18-inch blower, direct connected to a ½-H. P. motor making 1800 revolutions per minute. In the meat cutting room is an Enterprise meat chopper, driven by a 2-H. P. motor.

About six times as much oil was used in the original plant, which was a gasolene engine installation. The electrical installation obviates an increase in the expense of running the engineer's department, which is in charge of W. J. Gordon. An additional licensed engineer and a fireman would be required instead of the present arrangement of employees, in case motors were not used.

Notes on the Nernst Lamp

By MAX HARRIS

From a Paper Read at the Recent Convention of the Ohio Electric Light Association

SO much has been written and said about the Nernst system from the technical standpoint that no attempt will be made to cover this side of the question. The writer is of the opinion that for the daily problems to be solved in efforts to increase the sale of electric current, and in meeting the requirements of customers, a full knowledge of the practical results obtained will be of greater interest and value.

The Nernst system, as now marketed, consists of five units for use on alternating-current circuits of 110 or 220 volts, 25 to 133 cycles, for indoor and outdoor service, and popularly termed one-glower, two-glower, three-glower, four-glower and six-glower lamps. The manufacturer, after four years of practical experience in the installation of these units, has been enabled, for all practical purposes, to classify these units, as compared with other systems on the market, as follows:—

The one-glower lamp, consuming 88 watts at 220 volts, will successfully replace three 16-candle-power incandescent lamps, or one gas mantle.

The two-glower lamp, consuming 176 watts at 220 volts, will successfully replace seven 16-candle-power incandescent lamps.

The three-glower lamp, consuming 264 watts at 220 volts, will successfully replace ten 16-candle-power incandescent lamps, or one four-burner gas arc.

The four-glower lamp, consuming 352 watts at 220 volts, will successfully replace fourteen 16-candle-power incandescent lamps, or one 7½-ampere alternating-current enclosed arc lamp.

The six-glower lamp, consuming 528 watts at 220 volts, will successfully replace twenty 16-candle-power incandescent lamps, or one 7½-ampere alternating-current arc lamp, or one 5-ampere direct-current arc lamp.

The light emitted from the Nernst glower is absolutely steady at all times, mellow and pleasing, and of a colour best suited for the illumination of stores, public buildings, and generally for all classes of indoor illumination.

The basis upon which central stations should and do promote the use of Nernst lamps depends upon local conditions and the policy of the central stations. The manufacturer rightfully expects that this system shall be offered to the consumer on an equal basis with other illuminants. This being recognized as a reasonable and just position, it has been the policy of the central stations, which have already established the precedent of loaning apparatus, to also loan Nernst lamps as an inducement for the use of current. Other methods include a re-sale of the lamps at cost in many cases under deferred payment plan, and in some cases on a rental basis.

Wherever the policy of free renewals is in vogue, free maintenance of the lamps has been adopted. In some cases where consumers purchase renewals for incandescent and arc lamps, a fixed charge, usually 10 cents per glower per month, is made for the care and maintenance of lamps, or, inasmuch as the cost of maintenance is proportional to the wattage consumed, an additional charge of one-half cent per kilowatt-hour is sometimes added to the regular rate for current.

After all, the question of the method adopted is a simple problem in arithmetic. As an example, a lamp costing $12 would carry an interest and depreciation charge of $1.80 per year, or 15 cents per month, which charge may readily be included in the charge for current. Every central station manager can work out for himself a profitable method.

The demand for any article is based, first, upon its merit, and second, upon the publicity given the article and its advantages. It is a well-known fact that the use of or adoption of any device which will tend to lessen the cost of a commodity, be it electric current or otherwise, will, and does, result in the greater use of that commodity. In other words, to lessen the cost per unit of illumination will increase the number of units in use.

The manufacturer, recognizing this truth as applied to the Nernst system, has assumed the responsibility of educating the user of artificial illumination to the advantages of this system and effectively promoting its introduction.

An advantage of the system is its ability to hold customers who are dissatisfied because of insufficient illumination or high cost. It has been the writer's experience with this class of consumers that what they most desire is better and increased illumination without material increase in cost. This can invariably be accomplished by the installation of a sufficient number of units of proper size.

NERNST LAMP CO. Information Card No.....
City Columbus Ohio Date 6/10/06
Name .... Business ....
Address .... Phone ....

		GAS				ELECTRIC																
		Nat.		Art.		Arcs		Incandescents									Nernst					
		Arc	Bur	Arc	Bur	A.C.	D.C.	4c	8c	10c	16c	25c	32c	50c	75c	100	1g	2g	3g	4g	6g	Watts
Installation Present	Window										12											
	Store			4																		
	Total			4							12											600
Proposed	Window																	2				
	Store																		4			
	Total																					1400
Installed	Window																					
	Store																					
	Total																					

Salesman .... Recommended by ....

FIG. 1.—A CARD ON WHICH A SOLICITOR HAS REPORTED THE CONDITIONS OF LIGHTING IN A PROSPECTIVE CUSTOMER'S STORE, AND THE SUGGESTED USE OF NERNST LAMPS

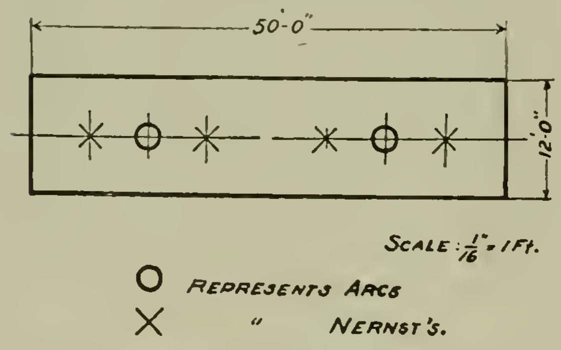


FIG. 2.—SHOWING THE ARRANGEMENT OF FOUR NERNST LAMPS FOR REPLACING TWO ARCS

Again, many merchants are using electricity for lighting their window displays and gas arcs for interior illumination. In this case, by cutting down some of the current consumed for the window display illumination and replacing the gas arcs by a complete Nernst installation, the consumer, at about an equal cost for a complete electric installation, replacing the former gas and electric outfit, is secured for the central station. The dual advantages to the central station are thus an increased sale of current and a load which, instead of being an entirely peak and after peak load, becomes a distributed load, with part of it in use during the day hours.

Fig. 1 shows the card used in some cities by the solicitors for reporting mixed installations to the contract agent of the central stations to enable him to pass upon the desirability of installing Nernst lamps. In this particular instance the consumer was using twelve incandescent lamps for window display lighting and four gas arcs for interior illumination. The proposed new installation would include two 2-glower lamps in the windows and four 3-glower lamps for the interior, showing an increase from a connected load of approximately 600 watts to a connected load of approximately 1400 watts.

Again, the installation of four 3-glower lamps instead of two arcs will invariably result in an increased use of electric current, as during the early morning and evening hours, when two arc lamps are too expensive for the average small merchant, such users will operate two of the 3-glower lamps. A typical illustration is shown in Fig. 2.

In many cases on record central stations have changed their flat rate to meter rate by installing Nernst lamps, and it requires no lengthy argument to convince one that in all such instances it is the proper move to install lamps of the highest efficiency available.

Where a central station changes from open-arc service, it is advantageous to employ Nernst units of varying sizes, and particularly is this so where the use of alternating-current multiple-arc lamps is contemplated, because of the unity power factor of the Nernst system and its other advantages.

As a means of presenting something new and novel to the prospective consumer, the first installations of such lamps, because of the distinctive form of the lamp and the colour of its light, will attract attention. Attention will arouse interest, which in turn will create inquiry, and inquiries, if properly followed, will result in the further introduction of lamps with a consequent increased sale of current, and with the further advantage that each lamp installed will shine out as an advertisement for the central station.

The Nernst lamp affords a means of obtaining a large volume of business which may be classed under the heading of "Advertising," such as window display illumination. It affords a means of broadening the peak, due to the ability of the central station to obtain a large number of small consumers, who, as a rule, have a connected load very nearly equal to their daily peak consumption. This class of consumers is better than a small number of so-called large consumers, who, as a rule, have a connected load greater than their usual daily-peak consumption.

Another advantage lies in the fact that while central stations have been trying "to sell current at the meter," they now generally recognize they must go further and act as illuminating engineers, and accordingly become more interested in actually selling illumination. With the Nernst system, this problem is made easier for the central station by reason of its many advantages: quality of light, efficiency, appearance and flexibility of the system.

In conclusion, attention is directed to the recent development of a series system of single vertical glower Nernst lamps for street lighting. Briefly, the system consists of placing in circuit on any alternating constant current circuit of 6.6 or 7.5 amperes, a series transformer with each single-glower lamp. The total wattage consumed by the series transformer and lamp is 115 watts. By the use of this system central stations are placed in a position to compete with the single-burner Welsbach gas system.

Electrical Equipment of the West Shore Railroad

SOME particulars of the electrical equipment of the West Shore Railroad are given in a recent isue of "The Railway Age." The section of the road undergoing electrification is that part between the city limits of Syracuse and the crossing of the railroad and Genesee street in Utica. This distance is 44 miles. The distance from the centre of Utica and the centre of Syracuse is 48.6 miles. The passenger schedule provides for limited trains in each direction leaving on the even hours and making the distance from downtown terminal to downtown terminal in 1 hour and 22 minutes, and trains each way leaving on the half-hour, making the run in 1 hour and 52 minutes, this latter service caring for local traffic.

The passenger schedule contemplated, taken in connection with the freight traffic which the West Shore would handle with steam-operated trains, required that one or two additional tracks be built over certain sections of the line. These additional tracks will enable the passenger trains operated by electricity at 55 and 45 miles per hour, respectively, to avoid interference with the freight trains operated by steam, which are of two classes, fast freights with a schedule of about 25 miles per hour and local freights with a schedule of about 15 miles per hour.

For the purpose of construction the line has been made into four sub-divisions, as follows:—

Genesee street, in Utica, to Vernon grade, 11.3 miles long, with a total of 31 miles of track.

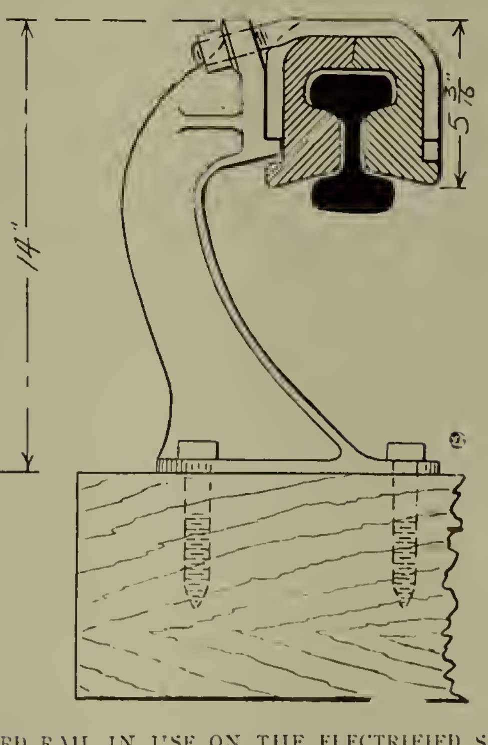
Vernon grade to Lenox avenue, Oneida, 10 miles long, with 24.5 miles of track.

Lenox avenue, Oneida, to Chittenango, 10.3 miles long, with 26.6 miles of track.

Chittenango to Syracuse city limits, 12.5 miles long, with 25.6 miles of track.

Work was started on May 15, and the installation of the third rail is practically complete on the first section. Third-rail ties are in place and rails distributed in the second section, and work on the third section was begun on August 1. The electrical equipment is being done by the Oneida Railway Company, of Oneida, a corporation organized under the earlier railroad laws and having a more liberal charter than could be obtained were a new corporation to be organized at this time.

The Oneida Railway Company has contracted with the Hudson River Electric Power Company for the delivery of three-phase current at a potential of 60,000 volts at the Oneida Railway Company's sub-station at Clarks Mills, about seven miles west of Utica. The Hudson River Electric Power Company will, for the present, generate this current at its auxiliary steam plant in Utica. Upon the completion of its trans-



THIRD RAIL IN USE ON THE ELECTRIFIED SECTION OF THE WEST SHORE RAILROAD

mission lines, current will undoubtedly be taken later from hydro-electric plants owned by this company in the eastern part of the State.

The Oneida Railway Company is building four sub-stations located about 10½ miles apart. These, counting west from Utica, are located at Clarks Mills, at a point 1½ miles west of Vernon, at a point 2½ miles west of Canastota, and at Manlius Centre, which is 5½ miles east of the Syracuse city limits. These sub-stations will be identical in construction, and each will be equipped with two 300-kilowatt rotary converters and the necessary equipment for transforming 60,000-volt, three-phase current to direct current for distribution to the rail at 600 volts.

The transmission line connecting the company's sub-stations will be of No. 0 stranded copper cable supported on narrow base steel towers. There are to be 391 of these towers, with a normal spacing of 480 feet, the great majority of them being 39 feet high; the highest are 63 feet, measuring from the top of the foundation to the bottom insulators. The insulators are of the four-petticoat type, 13½ inches high over all and 14 inches maximum diameter. The three conductors will be at the vertices of an equilateral triangle 7 feet on a side.

The third-rail construction is the Wilgus underrunning protected type, which is the standard adopted by the New York Central. The rail is a double-headed section, 4 3-16 inches high and 2 9-16 inches wide, weighing 70 pounds to the yard. The rail protection adopted is of two types. For all but 10 miles the protection is of yellow pine designed to give at least 1¼ inches of wood above the rail and on both sides. On ten miles of the third rail the protection is of fibre 3-16 inches thick moulded to conform to the outline of the rail section and sufficiently flexible to permit lengths of this to be slipped over the top head of the rail.

The induction-motor, says C. F. Lehman in "The Mining and Scientific Press," will, in his opinion, be the one used on most of the mine-hoists in the future. It is, however, a little better adapted to inclined shafts than to the vertical, as there is a certain amount of slack in the rope or cable and the motor has a chance to start under small loads, thus doing away with a more sudden rush of current on the line. With a proper controller and resistances for primary and secondary, and a design suited for this particular load, there should be no reason why this motor should not be adapted to any hoist up to 200 H. P. at least. Of course, it is understood that where large induction-motor hoists are used and other apparatus and lights are run from the same plant, the main plant must be of large enough capacity to take care of peak loads; also the power-wires should be of ample size for a maximum load so as not to cause a drop in voltage due to higher currents.

The Organization and Conduct of a New Business Department

For Central Stations in Cities of 50,000 Population and Under

By J. M. ROBB, of the Peoria Gas & Electric Co., Peoria, Ill.

A Paper Awarded Third Prize in the Co-operative Electrical Development Association's Competition

"SUCCESS lies in never tiring of doing, in repeating and never ceasing to repeat, in toiling, in waiting, in bearing and observing, in watching and experimenting, in falling back on one's self by reflection, turning the thought over and over, round and about the mind and vision, acting again and again upon it,—this is the law of growth. The secret is to do, to do it now; not to look away at all."

Bishop Spalding's definition of success fits the organization and conduct of a new business department as though he had it especially in mind when he penned these lines. The ability to increase the sales of current must be as assiduously cultivated as are studied the means of reducing costs and bettering your service. There is no central station so small that it can afford to get along without a new business department.

There is a general tendency to believe that others accomplish their work with less effort than ourselves, and this perhaps is responsible for the lack of confidence some central station men have in their own ability to conduct a successful new business department.

The busiest manager or superintendent, if he will persistently devote a few minutes daily to increasing his sales of current, will accomplish results as amazing as they are gratifying when he reviews them. Do not let anything prevent your beginning your new business campaign at once. Start now. Do not wait for printed forms, or to think out definitely how you will go about it. When you have made your beginning you will be astonished at the opportunities for new business that will develop in the most unexpected places.

Working a new business department is like popping corn. Your first efforts produce only a cracking sound, but no popped corn. If you stop now, your work is lost. But keep on; first one kernel pops and then another and another. Encouraged by these, more and more kernels pop until your popper fills as if by magic. If, most fortunately for you, your business seems to be in the condition of the full popper, remember the unpopped kernels that are always found when the popper is emptied. There are plenty of unpopped kernels of undeveloped electrical business in your territory which a little attention would convert into profitable income.

Naturally your first thought will be "How much money shall I spend to secure more business?" As the limit up to which money can be profitably spent for this purpose is in all probability beyond your means, your chief concern will be to use to the best advantage the largest appropriation you can get. Go slowly at the beginning. As a general rule, any expenditure for pushing your business will be beneficial, but there are great possibilities for waste. Hence the necessity for waiting, observing, watching and experimenting.

How shall you spend your new business appropriation? For solicitors? For newspaper advertising? Or for "direct-by-mail" advertising? The most efficient results will be obtained by a combination of all these methods. Newspaper advertising will awaken your public to the possibilities of electric service and prepare the way for your solicitors.

Solicitors should call upon possible customers, answer their questions, argue away their objections and clinch their orders, as well as investigate the troubles of present customers. They should explain your methods of handling the customers' business, and convince them that they are actually receiving full value for the money they are paying you.

Direct-by-mail advertising will excite the interest of those possible users of your service whom the solicitor cannot readily reach. It will back up his arguments with those he does see, and keep alive his prospective customer's interest between his calls. Each of the above divisions of business-getting, properly handled, will produce excellent results, but the most effective work can be done only with a combination of all three.

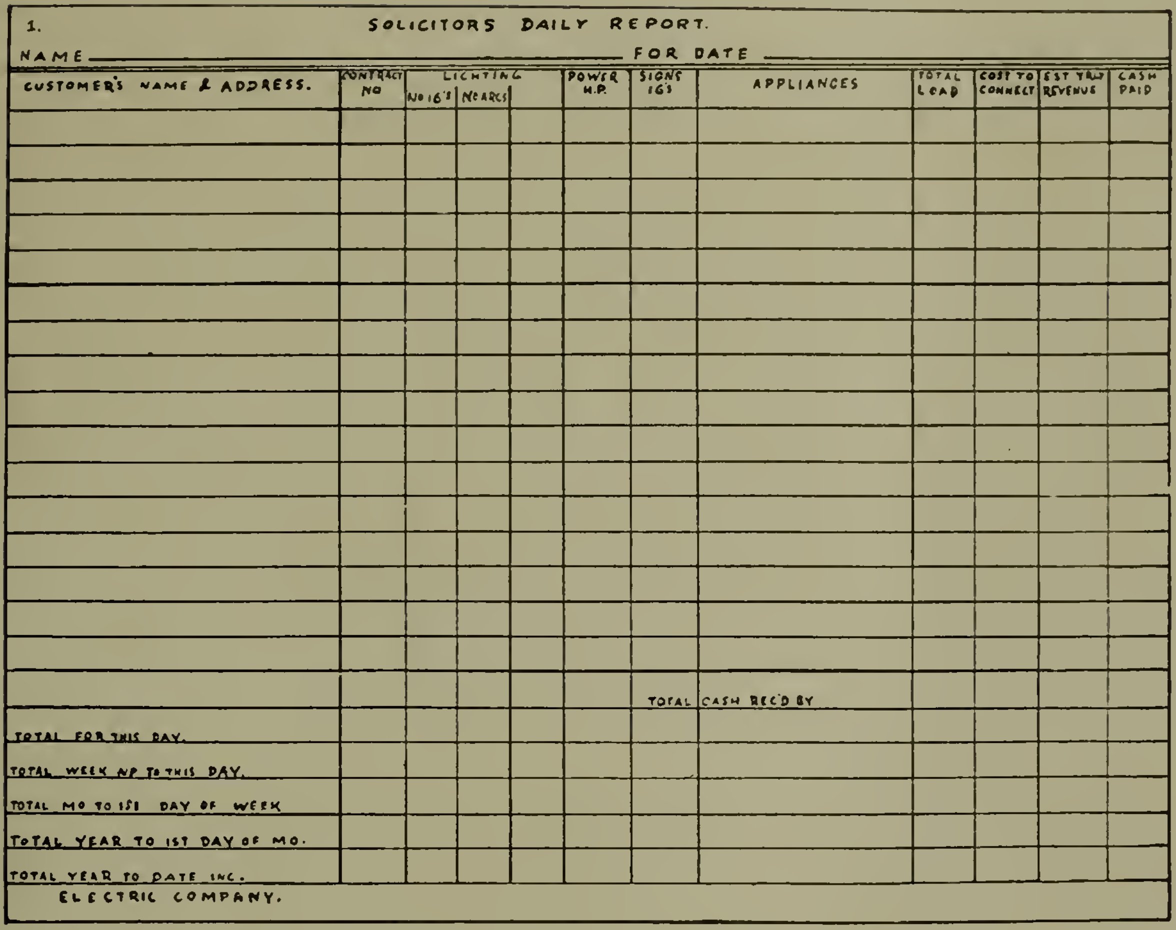
Endeavour to handle your new business appropriation so that your efforts will be continuous. If you must choose one of the three methods above outlined, by all means employ a solicitor and make strenuous efforts to keep him permanently at work.

SOLICITORS

In picking your solicitors, pay the most attention to their ability to handle people. For this work you must have salesmen, and a man who cannot handle people can never be a salesman. The "gift of gab" is not an essential, but the ability to talk convincingly is. Many a loquacious salesman spoils his work by talking too much.

Beware of the brilliant, sharp man, who works by fits and starts. Dependability is of the utmost importance. The slow plodder, who never forgets a point once mastered, will soon distance the speedy man who quickly catches on, but just as quickly tires if his first efforts are not successful. Persistency counts for more than dash. Few prospective customers are interested at the first call, and just as water constantly dropping wears away stones, so patient solicitation secures profitable business.

If you have, among your employees, a man who evidences selling ability, use him for a solicitor. Your solicitor must, of course, thoroughly understand your business, but this does not mean that he must start with a working knowledge. If your man is a real salesman, he may be ignorant of the electrical business at the start. A few days' coaching will fit him to begin your work and every day after will add to his knowledge. Some gas companies have made solicitors of their regular employees, in connection with their routine work,



1. SOLICITORS DAILY REPORT.

NAME ______________ FOR DATE ______________

CUSTOMER'S NAME & ADDRESS.	CONTRACT NO	LIGHTING NO 16'S	NO ARCS		POWER H.P.	SIGNS 16'S	APPLIANCES	TOTAL LOAD	COST TO CONNECT	EST YR REVENUE	CASH PAID
						TOTAL	CASH REC'D BY				
TOTAL FOR THIS DAY.											
TOTAL WEEK UP TO THIS DAY.											
TOTAL MO TO 1ST DAY OF WEEK											
TOTAL YEAR TO 1ST DAY OF MO.											
TOTAL YEAR TO DATE INC.											

ELECTRIC COMPANY.

FIG. I.—FORM FOR SOLICITOR'S DAILY REPORT

by paying them commissions on new business secured, with the understanding that the new business work would be pushed only outside of regular working hours.

Properly handled, this practice will produce results, and it possesses the additional advantage of arousing the men's interest in pushing your business. There is always danger, however, that the prospect of a commission will lead to neglect of some regular duty, and the practice is further likely to foment jealousy among the men.

An excellent way to pick solicitors is to advertise for salesmen and carefully study the applicants. You can soon pick out the effective men. The man who can't be earnest in advancing his own interests certainly won't make much headway in pushing yours. In searching for soliciting material, do not neglect to consider how a woman can push your interests, if you can find one of the right sort.

Having picked your solicitors, take time enough to thoroughly explain your business policy to them. Discuss with them your rates, your contracts, your customs, and your rules and regulations. Make clear to them the distinction between profitable and unprofitable business. Teach them to think in dollars and cents and give them enough data to enable them to estimate the cost of connecting any business they secure.

Take them over your plant and endeavour to make them appreciate the amount of work involved in rendering good service to your customers. If possible, make a few calls with each solicitor, letting him do all the talking, and then coach him between calls.

If you already have one or more solicitors, they can assist you in training the new men, but it will be to your best interest to let the beginners receive their first notions of your methods of handling your customers from yourself. Divide your territory into as many districts as you have solicitors, arranging as nearly as possible an equal division of business and residence territory in each district, so as to give each man an equal amount of possible business.

The size of your new business appropriation will determine the number of solicitors you can use. Some companies have profitably worked one solicitor to each 4000 of population. Each central station man must determine the number of solicitors to employ from his own conditions.

Your solicitors are now ready to go after business, but your work in handling them has just begun. It depends on you to arouse their enthusiasm to the highest pitch and keep it there.

Have the solicitors report to you each morning as early as convenient and canvass their previous day's work. Have a little "booster" meeting to start the day. Have each man tell of the orders he secured yesterday, the prospects he developed, and anything which helped him secure an order.

Encourage the men to discuss the business freely and to advance their criticisms and suggestions. Be liberal in your commendations of good work and sparing of criticism, but criticise sharply when circumstances require it.

As often as possible explain the operation of some appliance you are pushing. Demonstrate its good points and teach the men the arguments to down any objection that could be advanced by a prospective customer.

Use every means at your disposal to increase the men's knowledge of your business, constantly impressing upon them that any increase in their efficiency is to your mutual advantage. Note carefully any articles in trade papers, or any articles on salesmanship that will help your men, and specifically call their attention to them, asking the men to read them carefully and then tell you what they think of the matters discussed.

Have your men telephone to you at noon, both to let them know that you are following their work and to advise them of any prospects which may have developed in their respective territory since morning. Keep a blackboard record of each man's work brought up to date, to advertise to all the employees the work the solicitors are securing.

Have each solicitor turn in a daily report each morning, similar in form to Fig. 1. If any payments are collected, the amounts must be properly entered, footed and receipted by your cashier, or whoever is authorized to receive the cash.

The daily, weekly, monthly and yearly totals make possible an immediate comparison of each man's work, both with reference to current results and to results obtained in any previous period. This form should be printed on sheets in letter-head size and put up in pads. The completed sheets should then be filed in a vertical file, where they give a complete record of each man's work.

You must train your solicitors to be old-business retainers as well as new-business getters. They must realize that their own, their customer's and the company's interests are all bound together. Turn over to them for investigation the complaints of customers in their territory.

Have them look up the customer's apparatus, read his meter again, explain to him the methods used in handling his business and make a vigorous effort to convince the customer that he has the same check on his purchases of current that he has on his purchases of any other commodity. Energy expended to convince customers that they are receiving full value for the money they pay you is one of the most profitable means of securing more business. If your customers are made to realize that they are receiving their money's worth in service rendered, they will use your service much more liberally and be much more open to your suggestions for their use of more conveniences requiring additional current.

It is a mistake to pay solicitors commissions only on the sales of appliances. This practice will surely result in sales of appliances to customers who cannot advantageously use them, and will certainly cause much dissatisfaction and loss to you. A flat salary is preferable, and some managers adopt the flat salary method because of the labour required to record the results of each solicitor's work. The ideal method is a combination of a flat salary and a commission based upon the volume and value to the company of the sales of current effected by the solicitor, with a fine for business lost in the territory allotted to him.

One prominent gas company pays its solicitors a salary of $50 per month and a commission based on results secured, which is determined as follows:—

A pool is made each month, representing a certain sum for each solicitor employed. The various kinds of business to be secured are classified and given an arbitrary value of a certain number of points. The greatest number of points are assigned to business requiring no additional investment to serve and to business corresponding to sign and power business.

From this the business is graded down to the lowest number of points for business which is simply renewal business, due to consumers removing from one location to another, and business requiring a heavy investment for a relatively small income. To assist in the classification, the solicitor must report on a card the estimated cost of connecting the customer, as determined from a schedule furnished him in which are given the costs, as determined by the previous years' averages, of the various items entering into the total investment necessary to serve the new business. He must also report an estimate of the first year's revenue from the new customer.

The ratio between cost of connecting and volume of sales is considered by the new business department manager in assigning the number of points to the business secured. At regular intervals the solicitor's records are checked from the customers' ledgers, so that the tendency to overestimate the value of secured business may be offset.

A deduction of an arbitrary number of points is made for business lost in each solicitor's territory. At the end of each month each solicitor's points are totaled, and the percentage his total bears to the total of all the solicitors' points determines his share of the pool.

In this particular case the sum pooled for each solicitor is $25, making the average salary $75 a month for each man. Some of the solicitors on this basis earn as much as $125 a month. A better way is to determine what price you can pay for each kilowatt of new business secured, grading this price from a high rate for profitable business to a very low rate for business requiring a heavy investment, and no rate for unprofitable business.

Then agree to pay the solicitors a commission at these rates for a year for all business secured, having it understood that any business lost in their territory shall be deducted from the commissions at the same rates. Such an arrangement is mutually profitable for both solicitor and company.

The business secured can be readily determined if the backs of the Possible Business Index sheets be printed as shown in Fig. 2. The solicitor should be required to turn in with each order the corresponding P. B. I. sheet on which he has noted what his order covers.

If the order represents a customer already connected, the amount of the customer's business for the year previous to securing the order should be entered on the P. B. I. sheet and also the monthly average for the year. The sheet should then be filed in a secured business binder under the name of the solicitor securing the business.

Each month of the year following the date of the order, the amount of the customer's business should be posted to the sheets and the increased business credited to the solicitor at the agreed rate. Such an arrangement may be kept up with a minimum of work and may be modified to suit any set of conditions.

It would induce the solicitors to devote their efforts along channels most profitable to the company, and the deduction for business lost would insure their being old-business retainers as well as new-business getters. Under such an arrangement, the solicitor would have every inducement to make every effort to remedy complaints, and he would find it very unprofitable to waste his time selling appliances to customers who could not use them to their best advantage.

If the foregoing seems too complicated a method of handling solicitors, you would do well to reflect that the success of your new business department demands good men to carry on the work. You can secure the best work from good men only when you pay them in proportion to the results they secure for you. Any plan which will increase the efficiency of your men in secur-

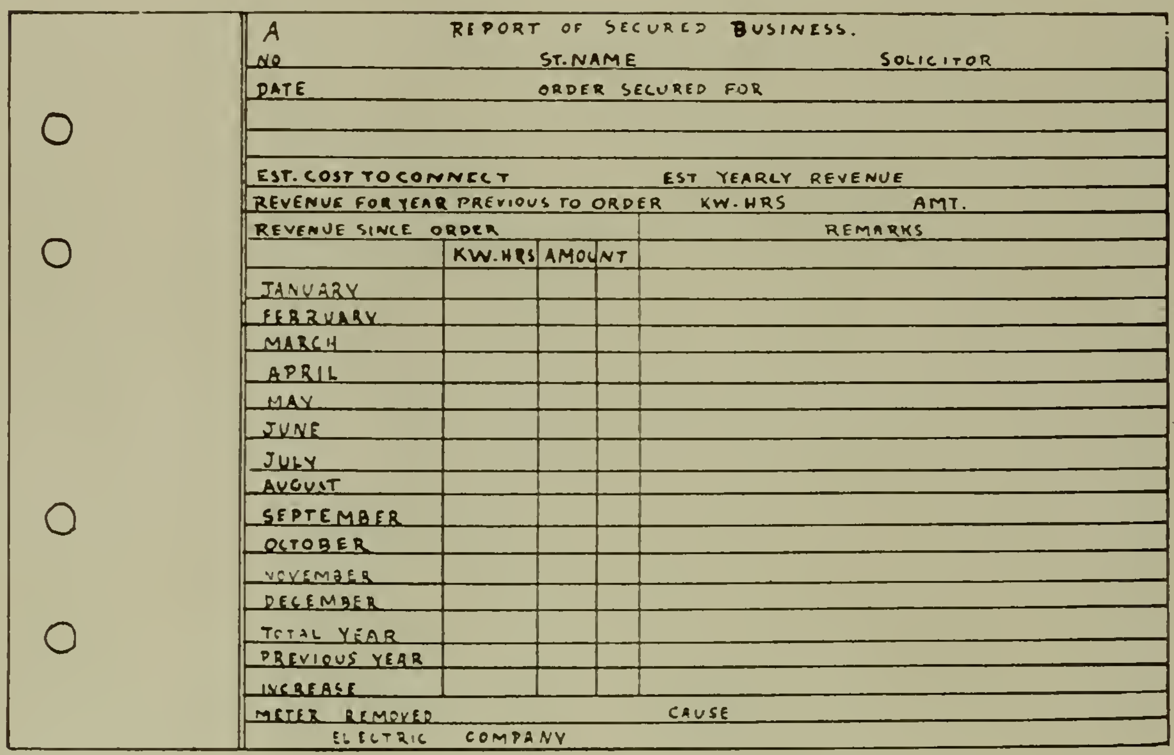
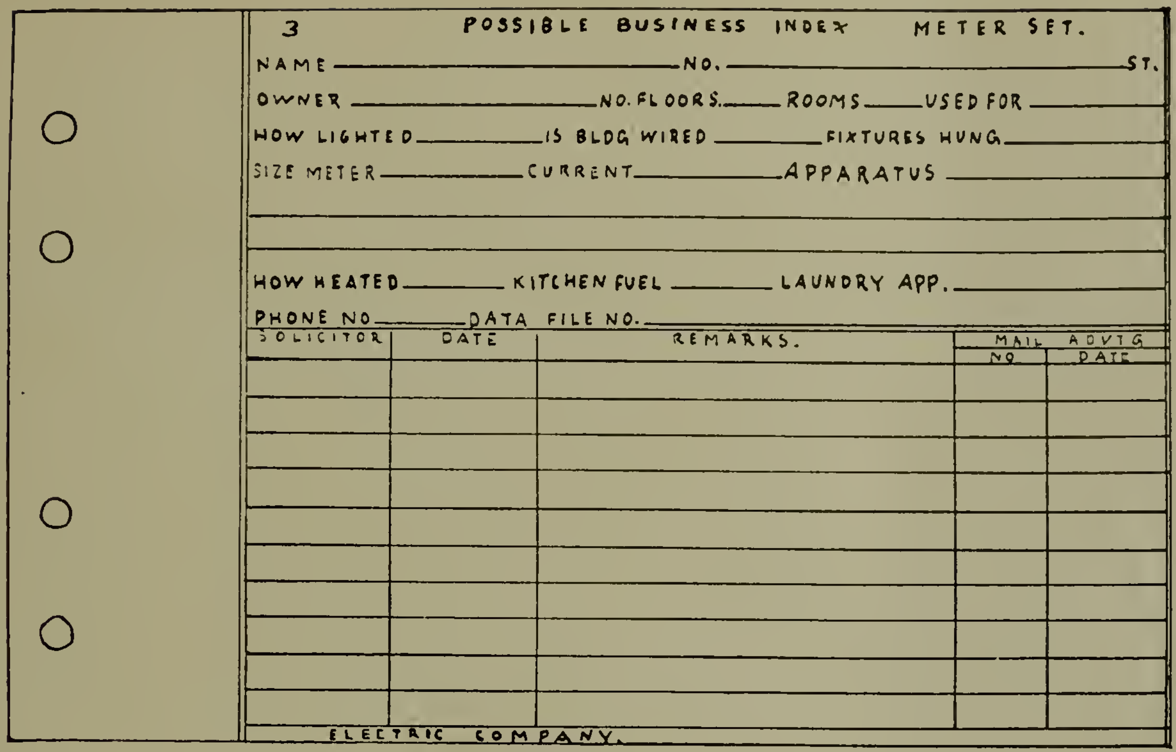
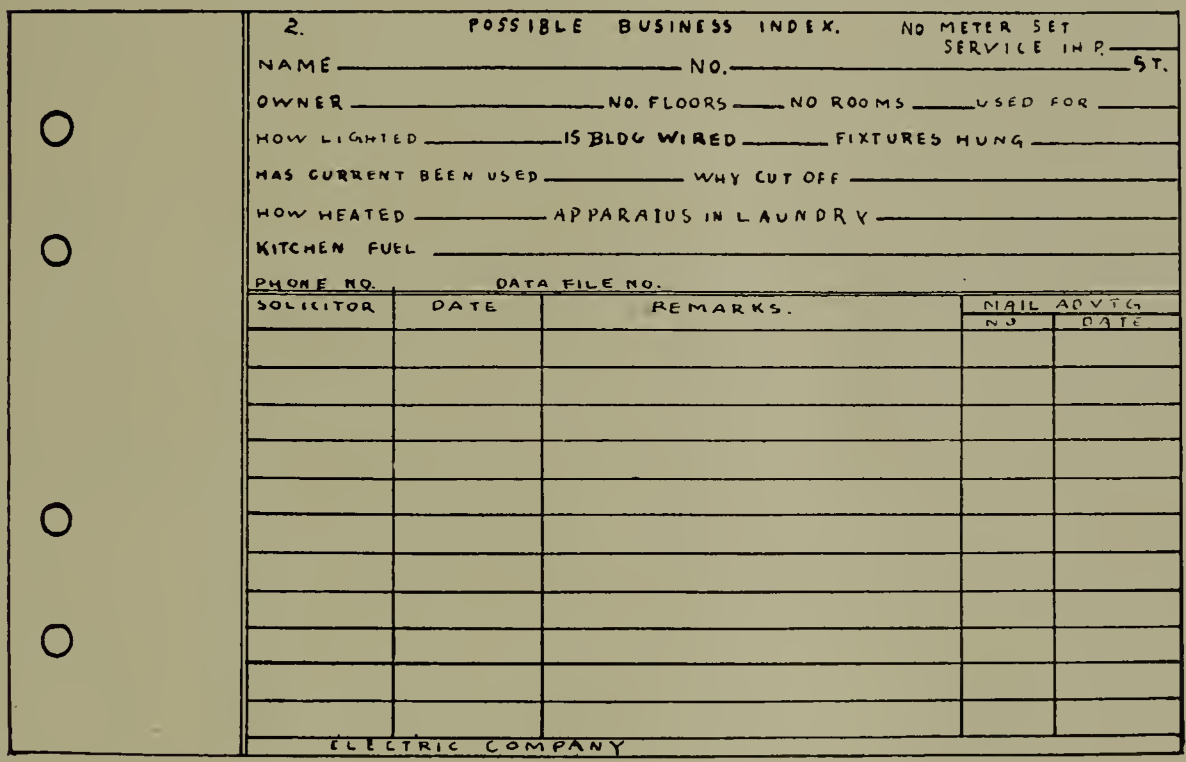


FIG. 2.—FORM FOR REPORTING BUSINESS SECURED





FIGS. 3 AND 4.—SUGGESTED FORMS FOR A POSSIBLE BUSINESS INDEX

ing more business for you, is mutually profitable to every one concerned.

POSSIBLE BUSINESS INDEX

One of the most necessary essentials of a systematic campaign for new business is a Possible Business Index.

Pope says:—

"Index learning turns no student pale,
But it grasps the eel of science by the tail."

That expresses the aim of a Possible Business Index. It is to the conduct of a new business department what plans and specifications are to a piece of construction work. No two men will work up their new business data precisely alike. Where one will want a complete plan, setting forth every detail, another will be content with a free-hand pencil sketch with a very few notes.

It is well to bear in mind that when a man goes hunting he must have quite a definite idea of what he seeks. If you have in your new business campaign a complete index of the possibilities in your territory, you will waste less of your new business appropriation.

While cards are generally used for such an index, loose sheets 5 by 8 inches in size and bound in binders will be found to be far more useful, and, in addition, will give all of the advantages of a card index.

Some of the advantages over cards are as follows:—

The sheets are larger, giving more space for useful data. The sheets bound in the binders will always be found in their proper sequence, and, if necessary, can be removed from the binder as easily as a card from a file. By using thin paper, much more information can be filed in a given space. By using a thin binder, it may be carried in the pocket, and in this manner the sheets are much easier to handle in the field than cards.

Figs. 2, 3 and 4 give a set of forms for a Possible Business Index. Fig. 2 is to be printed on the reverse sides of Figs. 3 and 4. These forms are self-explanatory. The telephone number is put in because often very effective soliciting can be done by telephone. The data file number is to be used when correspondence or estimates, etc., accumulate in soliciting prospective business.

An envelope, large enough to contain all the letters, estimates, etc., in flat sheets, is used, given a number and filed in your data files. The envelope number posted to the index sheet gives quick reference to all of the data on file for the prospective.

Your Possible Business Index should contain a sheet for each house or prospective in your territory. As your territory is extended, put in a sheet for each house or prospective in the new territory.

Arrange your orders so that every meter setting, removal or transfer order, and every appliance order, will go to the person in charge of the Possible Business Index, so that it will be always up to date, and show a complete list of all electrical appliances you are supplying with current. Remember that your index is your guide for directing your fight for more business, and the more careful attention it receives the less effort you will waste.

Use different colours of paper to indicate the different classes of new business. For instance, white paper can be used to indicate a building where no current has ever been sold, and yellow paper can be used to indicate a building now being supplied with current. Make the sheet for this class of business show an itemized statement of the connected load.

Red paper would indicate a building where current has been supplied, but, for some reason, has been disconnected. Brown paper would indicate power prospects, and green paper sign prospects.

Properly laid out and handled, the Possible Business Index will show not only the possibilities for business, but also the amount of work done on each prospect, and when the business is finally secured the index sheets can be used to keep a record of the business obtained by each solicitor. This is easily accomplished by noting on the sheets the orders to be credited to the solicitors and then filing them in a separate binder behind the name of the solicitor who is entitled to credit. Then, periodically, the revenue from such business can be posted to the sheets credited to each solicitor, and his income earning value is thus readily determined.

One of the best methods of starting your solicitors is to have them first go over their territory to make up reports for the Possible Business Index. In this manner the ice is more easily broken for a new man and he quickly becomes familiar with his territory.

Periodically, at regular intervals, depending upon your local conditions, have your man check up the New Business Index and carefully make the necessary corrections. If you are mailing matter to your prospective customers, this practice will not only save money in postage, but the moral effect on your prospective customers will increase the efficiency of your new business department many per cent.

To assist in keeping your Possible Business Index up to date, give your solicitors credit for any business closed in your office, where the index shows the solicitor has called on the customer within thirty days of the date of the order.

NEWSPAPER ADVERTISING

Your new business department can be made to prosper without the aid of newspapers, but, if you are wise and your appropriation permits, you will use them liberally and continuously. Properly used, the newspaper will aid you in moulding a favourable public opinion and it will also secure new business for you. If it does nothing else, it will pay its cost in the increased efficiency produced in your solicitors' work. The newspaper adds a dignity to the house-to-house work of your men which it would otherwise lack.

Use as much space as your appropriation will buy, but use it continuously. Don't splurge, unless your appropriation will stand it. Consider, also, how the average person scans his newspaper and you will realize that if you would have your advertisements noticed, they must be arranged so that "he who runs may read." This means that your newspaper talks must be very short, sharp, pithy, incisive. They must stand out so that upon the paper being opened the advertisement at once catches the eye. Plenty of white space must be used to accomplish this.

Give your newspaper talks direction. Select some person or prospective in your city, as nearly typical as possible, of the prevailing class of people whose business you are going to get, and address all your talks to him. It has been demonstrated in training street car conductors to call streets and stopping places, that announcements are much more easily understood if the conductor will direct his talk to some individual in the car, instead of just talking into space.

The same thing holds good in advertising. You are going to persuade people to buy your service. Very well. Point your arguments for some particular individual. Be direct; come to the point at once.

Use old-fashioned plain English, the kind that says "Keep Out" instead of "No Admittance," or, "Come In," instead of "Visitors are Welcome." Use common sense. "The man who has the truth in his heart need never fear the lack of persuasion on his lips."

It is not necessary that you be able to write flowing sentences. You have a story to tell. Imagine that you have your prospective customer up in a corner where he cannot get away. Talk to him, but be brief. Select some phrase to correspond with "Cook with Gas." Use it to head every advertisement and follow it with a reason why.

Here are some suggestions:—

LET ELECTRICITY DO YOUR WORK.

GET AN ELECTRIC IRON. THEN YOUR IRONING WILL BE DONE WITH HALF THE TIME AND WORK. ONE WILL BE SENT TO YOU ON THIRTY DAYS' TRIAL IF YOU 'PHONE TO NO. ......

GET AN ELECTRIC WARMER FOR BABY'S FOOD. THEN YOU WON'T HAVE TO CHASE DOWNSTAIRS NIGHTS TO THE GAS STOVE.

PUT UP A PORCH LIGHT, WITH THE STREET NUMBER ON THE GLOBE. KEEP IT LIGHTED EVENINGS. LET YOUR FRIENDS KNOW WHERE YOU LIVE WHEN THEY CALL.

HOW ABOUT THE WEAR AND TEAR THAT CLOTHES WRINGER TAKES OUT OF YOUR CLOTHES? AN ELECTRIC CENTRIFUGAL CLOTHES WRINGER WILL SAVE IT.

EVER HUNT FOR THINGS IN YOUR CLOSETS WITH MATCHES? ELECTRIC CLOSET LIGHTS ARE CHEAP FIRE INSURANCE. PUT THEM IN NOW.

DO YOU USE A CHAFING DISH? SEE THE ELECTRIC CHAFING DISHES AT (YOUR ADDRESS).

DOES YOUR WIFE SEW?
SHE CERTAINLY WILL APPRECIATE AN ELECTRIC MOTOR TO DRIVE HER MACHINE. ORDER ONE ON TRIAL.

DO YOU USE POWER?
AN ELECTRIC MOTOR WILL FURNISH IT AT LESS EXPENSE THAN ANYTHING ELSE YOU CAN GET. TELEPHONE NO. .... FOR PARTICULARS.

AN ELECTRIC FAN WILL CHASE THE FLIES OUT FOR YOU. SEND IN YOUR ORDER NOW.

Change your copy every day. This is important, and it will lead many people to look up your advertisements to see what you will say next. The more people you can get to think about your business, the faster it will increase.

Keep a scrap-book file containing copies of every advertisement you run. If you will arrange your scrap-book in the order in which your advertisements appear, it will form an excellent means of checking your monthly newspaper bills. Study every advertisement that comes to your notice, in your endeavour to make your own advertisements different from the others with which it is printed. The effort will pay big returns.

DIRECT BY MAIL ADVERTISING

A campaign of direct advertising by mail will still further increase your solicitors' efficiency. Mail will easily reach customers who will never see a solicitor, or get to them at times when a solicitor's call would be considered an intrusion and resented. Be chary, however, of your use of circular letters and do not place too much faith in the selling power of multi-coloured, direct-by-mail stuff, artistically folded like a table cloth or bed sheet.

Business men to-day are busy. A sentence in black type on a plain postal will make an indelible, unconscious impression, where a choice collection of pictures on a square yard of wrapping paper will only produce an emphatic "cuss" word and a vigorous shove toward the waste basket.

The chief value of a circular letter is its personal appeal. In that is found the necessity for its preparation with consummate care, to give it all the effect of a personal appeal to the reader. Most circular letters are an abomination, and unless you are sure of your ability to convince your man that it is his interest and business, not yours, that you are pushing, you would better stick to your postals.

If you do send out circular letters, enclose with each one an addressed postal,—not a mailing card without a stamp,—so that when your letter makes the desired impression, the postal will be mailed before your prospective customer changes his mind in hunting for a 1-cent stamp.

Be sure, too, that the postals are numbered for identification, for sometimes prospects mail cards, forgetting to sign them. If you have an addressing machine, have the addresses of your prospective customers set up for it and arrange to keep it up to date. This will put you in position to effectively and quickly reach your prospective customers with any proposition you want to push.

Number consecutively the printed matter, mailing cards, circular letters, etc., that you send out; keep a scrapbook with copies of all such matter and have the date and number stamped upon your Possible Business Index sheets. By tabulating the orders secured from each lot of matter mailed out, as shown by the entries on the Possible Business Index, you are in position to judge the effectiveness of what you are distributing.

CO-OPERATION WITH EMPLOYEES

Do not end your work among your own men with training your solicitors. Work up the interest of every man connected with the company. Make them all see the possibilities that can be obtained if every man makes use of the opportunities that come to him every day for boosting the company's business.

Organize a progress club among the men, with meetings to be held monthly or oftener, at which matters relating to the service, the sales of appliances, their use, the betterment of the service, etc., can be discussed. Invite their criticisms and study their suggestions. This work will cost much in time and energy, but better results will be secured than can be obtained in any other manner.

SALESROOM

Your salesroom is a most important adjunct of your new business department. First impressions count for everything with some people and for something with everybody. Your conditions will govern the quantity of apparatus you can display, but even if you show only a flatiron, you can show it, if you will, so that it will attract interested attention.

Don't neglect to have a glass case wattmeter connected up, so that you can demonstrate its operation at any time. Make use of the pamphlets, etc., that manufacturers of electrical apparatus will supply you for the asking. Everything helps.

CATALOGUES

Keep carefully filed, for reference, every catalogue of current-using apparatus you can obtain. Study your catalogues and have your solicitor study them. They will suggest endless applications demanding the use of current, many of which can be profitably used by your consumers.

APPLIANCE POLICY

Make your selling prices for appliances bring you the same rate of profit a dealer would expect, but scrupulously put into advertising or soliciting every cent of such profit. This practice will encourage dealers to handle electrical appliances. Co-operation is what you need, and the more people in your territory who can be induced to push electrical appliances, the better will it be for you. The practice of selling appliances at cost or less than cost, further, has the tendency to confirm the popular opinion of the profits from the sale of current. Then, too, many people measure the value of an article by its price, and emphasizing the low price of what you are selling depreciates it to them.

Selling electrical appliances is more a matter of salesmanship than price. Convince your customers of the value of your service. Create in them a desire to use it. It can be done by persistent work. Make your terms easy,—small payments on long time,—and they will buy.

Offer every appliance you handle on trial long enough to thoroughly demonstrate its convenience and utility. Follow up every appliance sold with a careful inspection, to ascertain that it has been properly set and that its operation is thoroughly understood. Push forward the merits of your service and leave price the last thing to discuss when you have shown how desirable and useful a thing your service is.

In exceptional cases, your margin of profit will permit you to arrange exchanges to secure profitable business which you could not otherwise get, because of the customer's investment in non-current-consuming apparatus.

CO-OPERATION WITH CONTRACTORS

Display in a prominent place in your office a wall directory of all the electrical contractors in your territory. Arrange to send them immediately any tips coming to your notice concerning wire work, etc. Keep in touch with them, establish friendly relations with them, and consider their criticisms and suggestions. Their co-operation is a valuable means of extending your business and is well worth your strenuous efforts to secure and hold.

Keep informed of the local work your architects have in hand and arrange for regular reports from the building inspector's office. Knowing in advance of projected new buildings or remodeling work, you can furnish advance information to your friends, the contractors, and their self-interest in securing the work will make them efficient solicitors for you.

PUBLICITY

Make use of every legitimate means of securing desirable publicity for your company. Establish friendly relations with the editors and reporters of your newspapers. In most small towns, news items are not plentiful, and much profitable publicity can be secured through tactfully acquainting your newspaper man of current happenings, such as contracts closed, contemplated improvements, etc., or handing them an occasional clipping describing some electrical appliance or some new application of electricity.

Should you, unfortunately, have an accident, prepare your own version for the papers. It will save them the trouble of writing it up and insure your public having the story as you want it told. Remember that your business is bound to receive a certain amount of attention from the press. If you will make the effort, you can direct it to your advantage.

Make every piece of company property carry its advertising message. If there is no ordinance prohibiting it, put a permanent enameled sign on every one of your poles. You need not incur the expense of equipping all the poles at one time, but by buying permanent signs you can put them up on the installment plan without finding the expense too heavy a burden.

The benefit to be obtained by circulating a monthly bulletin among their customers and prospective customers is not properly appreciated by central station men. Most electric men fully realize the benefits their companies bring to the community they serve, but too many forget that there is no one except themselves to exploit these benefits to obtain the public appreciation they merit. Electric men, and gas men too, for that matter, have too long been guilty of "hiding their light under a bushel."

Energetically pushing forward the many advantages of electric service, both to the customers and to the community as a whole, will do more than anything else to disarm the hostile spirit too often manifested against central stations. There is no one to do this save the central station men themselves, and no better way to accomplish it than the monthly bulletin.

The practice of advertising appliances on or with monthly bills for service is of doubtful value. The recipient of the bill is then in the least receptive mood for suggestions to increase his use of current. The bulletin method is more costly, to be sure, but it deserves careful consideration among the other plans for extending your business. Give your wagons, tool carts, etc., especial attention. Paint them often and keep them clean. Make your entire equipment carry its message of wide-awakeness and progressiveness to your community.

CULTIVATE POPULARITY

Aim to be considered in your community as a public benefactor. Use a portion of your new business appropriation for purchasing advertising space in programmes for church entertainments, and the like. The space so purchased has little advertising value, but when the character and energy of the people behind the church and charitable organizations is considered, the importance of securing their good will is apparent.

The amount paid in each case need only be a small one, but it is important that this matter be so handled as to build up a co-operative spirit and that your customers appreciate that you are anxious to lend your assistance to anything promoting the public welfare. In this line of work, beware of the professional advertising scheme promoters.

If possible, arrange to loan cooking and other apparatus to church and charitable organizations free of charge, including current used. Stipulate, however, that a representative of your company shall superintend its operation to demonstrate the apparatus and to make use of any opportunity to promote your interests that may occur. Your efforts along this line of work will certainly go far toward establishing your company solidly in the good graces of your customers and possible customers.

Never let any adverse criticism of your company, by any individual in your community, go unanswered. Public service companies have so generally neglected to answer hostile criticisms that the public generally has come to consider that they have no answer.

Whenever you hear of a disgruntled individual, ascertain as quickly as possible what his grievance is, and either show him where he is wrong, or right his trouble. You will find a few people whom you cannot convince, but your efforts in this direction, persistently followed up, will bear rich fruit.

CONCLUSION

You have doubtless noticed that there is nothing new or radical in what has been advanced in this paper for the organization and conduct of a new business department. These things have all occurred to every man who has given persistent thought to the work, and will occur anew to the men who will engage in it later.

It would perhaps be difficult for any one man to follow all the lines suggested, but every man doing central station work can, if he will, start with some one line of effort in this direction. The start is the all-important thing, for if the work be followed up, new ways and methods will be constantly suggested to the persistent worker.

Thoreau says:—"I learned this—that if one advances confidently in the direction of his dreams he will meet with a success unexpected in common. If you have built castles in the air, your work need not be lost; that is where they should be—now put the foundations under them."

This also applies to the new business work. Dream your dreams of satisfied customers lighting their homes, their factories and their stores with your current, driving their machines with your power, cooking their meals with your appliances, advertising their business with your signs. Then work, work day and night, to make your dreams come true. Work,—everlasting, never-tiring, patient, persistent work,—that is the secret of a successful new business department.

Nernst electric lamps have been selected for the New York terminal of the New York, Pennsylvania & Long Island Railroad Company. Not only is the vast main building to be lighted, with its waiting rooms, dining-rooms, arcades with shops, offices for railroad officials, baggage rooms, driveways, a concourse, train platforms, etc., but there are also to be lighted several miles of tunnels and approaches, and large terminal yards. Every variety of lighting service is called for, and the predetermination of the energy required was the first problem to settle. On account of the economy of the Nernst lamp, the plant required will be remarkably small, about 20,000 glower units being specified.

Variations in Voltage on British Lighting Systems

IN a paper on "Glow Lamps and the Grading of Voltages," read at the recent meeting of the British Association for the Advancement of Science, Sir W. H. Preece said that the most serious disturbance in British systems of distribution of electrical energy, and a prolific source of decay and destruction of incandescent lamps, is the variation of voltage, not only from the specified standard pressures, but in any one system, from the individual pressure adopted in the network of that system. This latter variation is an evil, not only in the feeders, but in the service lines, and frequently in the internal circuits of lamp installations.

No serious attempt has yet been made to secure uniform pressure throughout the network of distribution systems by introducing voltage regulators. The departure from the standard pressures of 110 volts and 220 volts adopted by the Engineering Standards Committee is shown by the following table:—

Voltage of Circuit	Lighting Kilowatt	No. of Generating Stations
100	72,701	54
102	463	1
103	160	1
104	2,824	1
105	7,308	6
107	3,567	1
110	7,523	11
115	5,103	3
120	120	1
150	2,379	3
200	129,690	81
204	16,603	2
205	3,142	1
210	21,361	26
214	3,568	1
215	479	1
220	66,935	82
225	144	6
230	104,720	122
235	88	1
240	45,389	57
250	18,249	10
	512,516	472

In 472 systems only 11 adopt 110 and 82 adopt 220 volts, while 122 employ 230. Most of these, however, were established before the Standards Committee was formed, but many have been established since.

A commission nominated by the Italian Government has just estimated the total available water-power at 3,750,000 H. P. There are in the fifty-eight Italian provinces 24,486 waterfalls, which have together a mean power of 2,000,000 H. P.; of this amount 38 per cent. is situated in the north, 26 per cent. in the centre, and 30 per cent. in the south, the small remainder occurring mainly in Sicily. In addition to these existing falls, the great rivers can furnish 575,000 H. P., of which 130,000 is already taken up; the Tiber alone can supply 375,000 H. P., and already gives 75,000 H. P.

The Power Plant of the Electrical Development Company of Ontario

By F. O. BLACKWELL

A Paper Read at the Recent Convention of the Canadian Electrical Association

THE power plant of the Electrical Development Company was designed to utilize 11,200 cubic feet of water per second under a head of $135\frac{1}{2}$ feet, diverted from the Niagara River at Tempest Point, midway between the headworks of the Ontario Power Company and the Canadian Niagara Falls Power Company.

The general plan of development adopted called for the construction of a wing wall to gather the water from the rapids, the excavation of a forebay of sufficient capacity with the river at its lowest future stage, a wheel pit, and a tailrace tunnel discharging under the centre of the Horseshoe Falls, where the flow of water over the Falls is greatest. The forebay in the rapids and the tunnel outlet under the Falls were both bold and original conceptions, which were thought at the time to be practically impossible of execution.

In order to uncover the forebay, it was necessary to construct a coffer dam 2200 feet long in the rapids, where, for a portion of the way, the cribs had to be sunk in water 26 feet deep and running at a velocity of 22 feet a second. This work was started in April, 1903, and proved to be an extremely difficult undertaking, but was successfully completed in about twelve months.

In May, 1903, the tailrace tunnel was started by the sinking of a construction shaft on the bank of the river 150 feet deep and 15 by 7 feet inside the timbering. From this shaft a drift 14 feet wide and 7 feet high was run 670 feet to the portal of the tailrace tunnel, work upon which was only actually started in December of the same year. The final opening under the Falls proved very difficult on account of the large amount of water encountered near the face and the mass of detritus that had to be cleared away by men exposed to the full force of the wind and spray from the Falls.

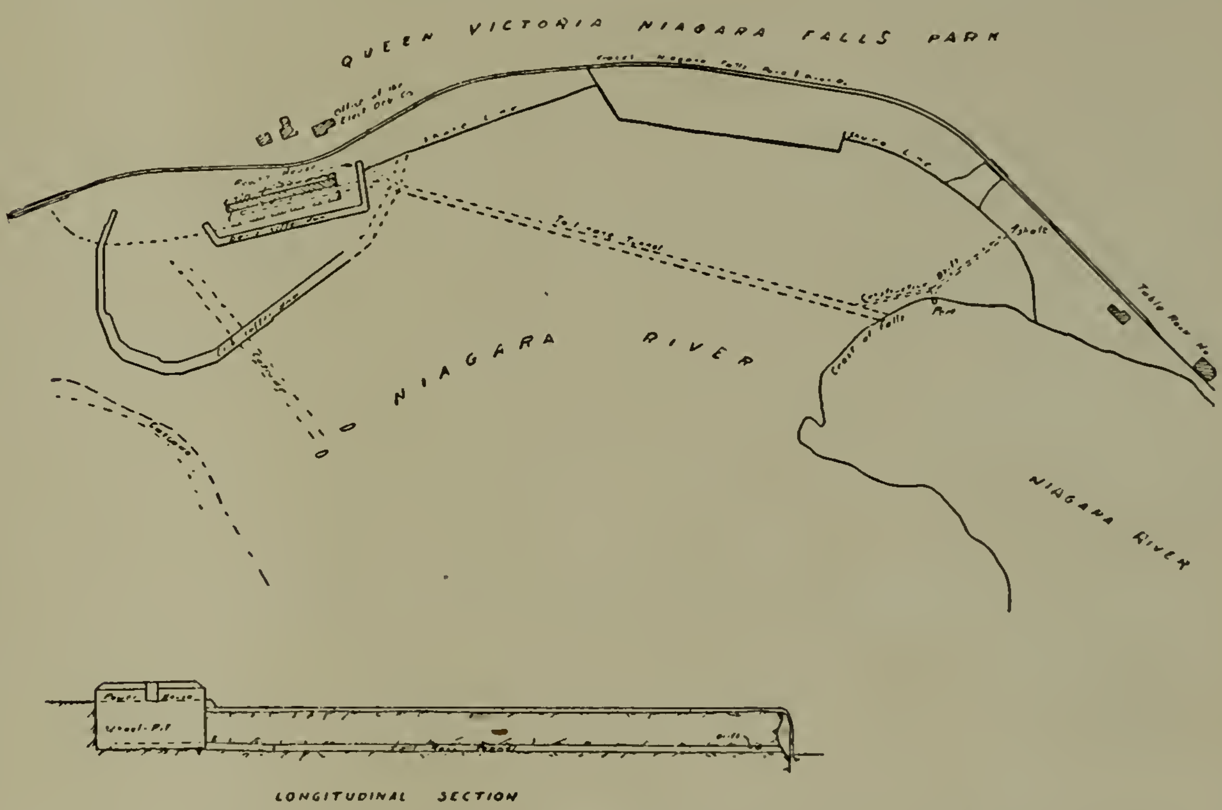
The wing dam is 785 feet long, and its maximum height is 27 feet. The elevation of the crest is 527 feet, and there will be from 3 to 8 feet of water flowing over it, depending upon the condition of the river. Near the power house the dam is cut away for a length of 30 feet to an elevation of 524 feet, so that there will be 3 feet additional depth of water to carry away ice from the submerged arches in front of the power house.

This question of guarding against ice is one of the most important problems which had to be met. In addition to the first line of submerged arches just referred to, a second wall has been constructed outside of the racks. The spaces between the outer and inner walls, and between the latter and the racks, are arranged each with a spillway at one end, so that such ice as passes through will float out at the north end of the building.

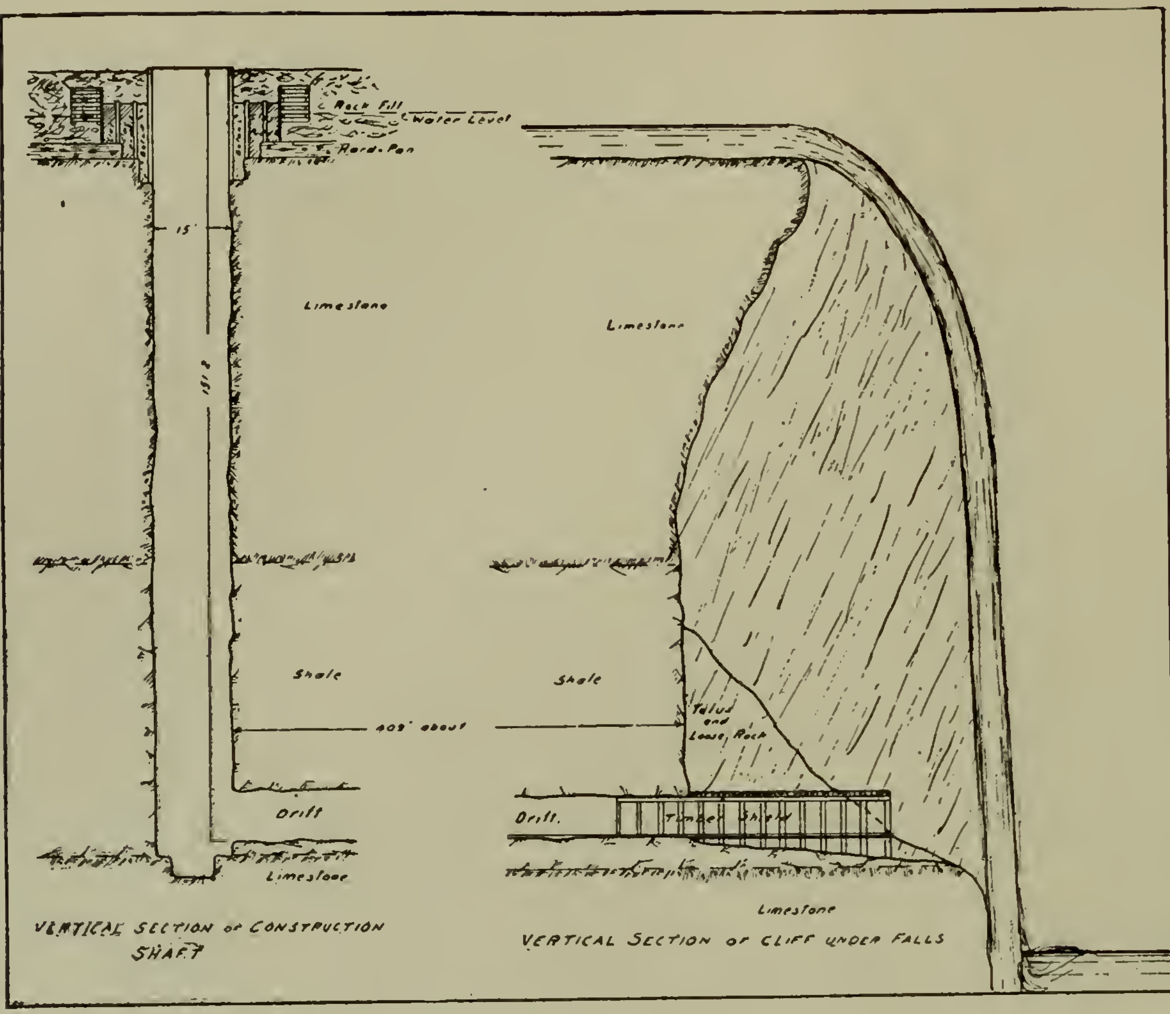
The wheel pit is 416 feet long and 22 feet in width inside of the brick lining, which is 2 feet thick, and is spanned by masonry arches at three levels to carry the machinery. The ends of the pit are also closed by arched wall linings. The arches were not allowed to be put in until the pit had closed in as much as it would and come to rest. There has been no movement whatever at the union of the arches and the walls that the most accurate observations could detect, which is interesting on account of the theory once advanced that there was a periodic change in the distance apart of the sides of the pit.

For the power to be developed, the length of the wheel pit is much less than in previous developments of this character. This is due to the penstocks alternately being on the right and left-hand sides of the water-wheels, permitting one hoistway to serve two wheels.

The water, after passing through the racks, enters a cast-iron bellmouth, which in turn joins on to a riveted steel penstock 10 feet 6 inches in diameter. There are eleven penstocks, and at the head of each an electrically operated gate controls the water. The penstocks are connected at the bottom to water-wheels



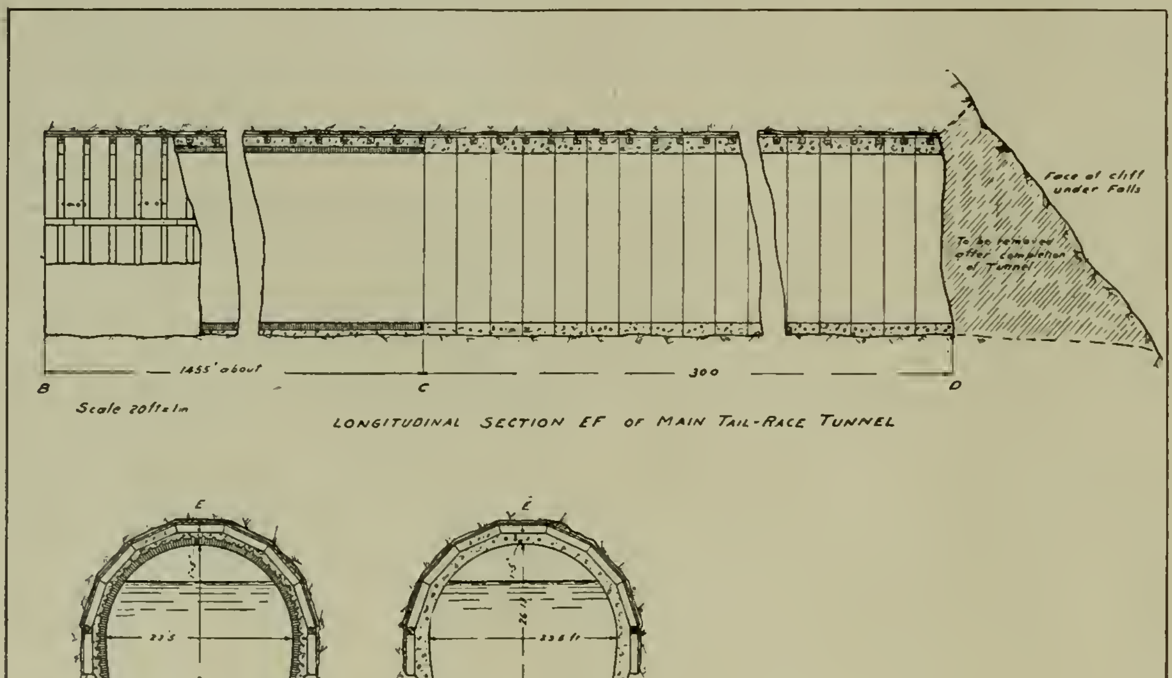
GENERAL PLAN OF THE ELECTRICAL DEVELOPMENT COMPANY'S UTILIZATION OF NIAGARA POWER



VERTICAL SECTIONS OF THE CONSTRUCTION SHAFT AND DRIFT UNDER THE FALLS

of 13,000 H. P. capacity, running at a speed of 250 revolutions per minute. The wheels and penstocks rest on a heavy concrete foundation, which covers the bottom of the wheel pit. The hydraulic apparatus is being furnished by the I. P. Morris Company, of Philadelphia.

Each wheel unit consists of two Francis internal discharge turbines 5 feet 4 inches in diameter. The discharge of water is to be governed by cylinder gates, and the weight of the moving parts will be partially taken by a water piston in the wheel. A single cast-iron draught-tube 9 feet in diameter is provided for each wheel, and the units alternately discharge water underneath the east and west tailrace tunnels.



LONGITUDINAL AND TRANSVERSE SECTIONS OF THE TAILRACE TUNNEL

The object of the under discharge is to seal the draught tubes and prevent loss of vacuum, no matter what the elevation of the water in the tunnels may be, and without the necessity for a tailrace weir. By using two tunnels it is possible to shut off the water entirely from one-half of the wheels without interfering with the other half.

By closing down the wheels, discharging water into either tunnel, that tunnel will drain itself, and there is no necessity for closing off the mouth of the tunnel. A gate is provided at the mouth of both tunnels, however, in case of extreme back water, which has been known to be 50 feet above normal in the lower river. As the wheel pit is not connected to the tailrace, the hydraulic apparatus can never be flooded out.

The tunnels on each side of the wheel pit are 25 feet deep, and vary in width from 66 to 30 feet, with a velocity of from 15 to 21 feet a second. At a point about 150 feet north of the wheel pit the tunnels come together. At the junction the tunnel is 35 feet wide and 25 feet 6 inches high, and tapers to a width of 23 feet 5 inches and a height of 26 feet 13 inches, which section is carried to the edge of the Falls, a distance of 1935 feet.

The slope of the main tunnel is 0.005, making the total loss about 10 feet, and the velocity is 26 feet a second. The tunnels have a lining 2 feet thick throughout of concrete faced with brick, except for 300 feet at the north end, where the lining consists of concrete rings in 6-foot sections, which are expected to break off as the Falls gradually wear away. This is necessary, as the crest in the centre has been receding at an average rate of 2½ feet a year.

The power of the water-wheels is delivered to the electric generators through vertical shafts 150 feet long, consisting of riveted steel tubes 30 inches in diameter between bearings and solid shafts 14½ inches in diameter at bearings. This shaft is held at three points in the wheel pit by steady bearings resting on concrete arches. At the upper end there is an oil thrust bearing 37½ inches in diameter fed by oil under a pressure of 350 pounds, which is sufficient to carry the weight of the entire revolving parts should the water thrust fail from any cause.

There will be ultimately eleven 8000-KW. generator units, four of which are now being installed by the Canadian General Electric Company. These are of the revolving-field type and run at a speed of 250 revolutions per minute. They deliver three-phase alternating current at a periodicity of 25 cycles and a potential of 12,000 volts. There are at first to be two 500-KW. water-wheel-driven exciters in a room underground, and two motor-generator sets of the same capacity on the generator floor. Eventually three sets of each type will be installed, any two of which will excite all the alternators.

The controlling switchboard for the entire plant, including transformers and transmission lines, is located in the centre of the power house, where the operator can see the generators. It consists of an enclosed compartment with a bench-board in front and doors at the ends. The instruments which are ordinarily employed in the operation of the station face towards the generator room.

On the back are the recording instruments and switches, which are only occasionally used or referred to. Dummy bus-bars and signal lamps on the bench-board clearly indicate to the operator the connections in the station, and the instruments are so located that each is over the switch which controls it. The generator instruments, for instance, are over the generator control switch.

The board is so compact that an operator standing in front of it can see all the instruments from one position, and can conveniently reach all the controlling switches. The power house bus-bars, generator oil switches, instrument and switch transformers are located immediately below the power house floor in brick compartments. The wiring arrangement is such that a generator can be connected either to the bus-bar or to a separate outgoing cable. In ordinary operation, the current from each generator will leave the building by the shortest possible route, and there will be practically no cables running the length of the power house.

The power house will be a handsome building in the style of the Italian Renaissance, about 500 feet long and 70 feet wide. The height will be 40 feet, except at the centre and end bays. The centre bay will stand out from the face of the building, and, besides being the main entrance, will give room for the offices of the company. On the inside it will also afford space for the switchboard and auxiliary apparatus. The power and transformer houses are 1817 feet apart, and will eventually be connected by four underground conduits. One conduit will be in reserve, and the plant will not be crippled unless two conduits should simultaneously fail.

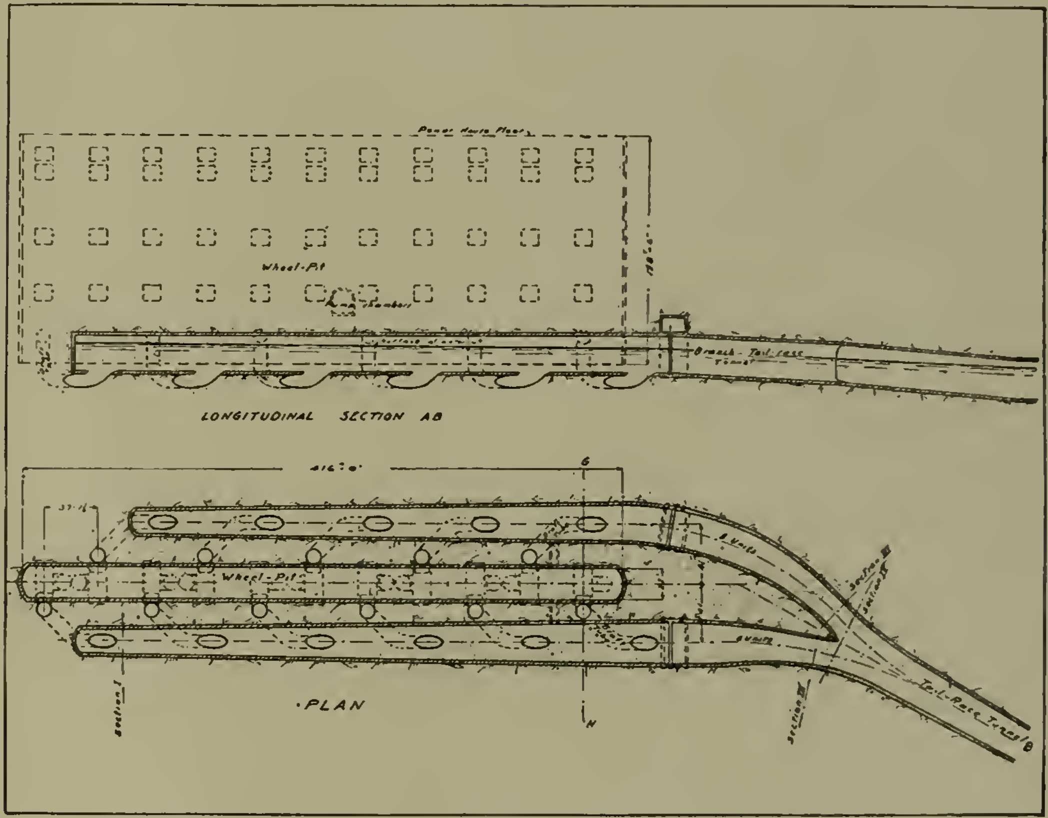
At present two conduits only are constructed, each with sixteen 4¼-inch ducts placed two wide and eight deep. The manholes are common to the two conduits, but are divided into two parts by a central partition, so that one duct system would not be damaged by a burn-out on the other.

The cables required for the portion of the power plant first installed are six 500,000 c. m. triplex for 12,000-volt power, two No. 00 B. & S. for the switch motor bus-bars, two with 45 No. 8 B. & S. wires for oil switch control, two each of 13 No. 12 and 14 No. 7 wires for instrument connections. The cables are in duplicate, and either half of the ducts might be disabled without shutting down the power system.

The transformer house is on top of the bluff outside of the Park limits, and is designed to accommodate fifteen 2670-KW. transformers furnished by the Canadian General Electric Company, twelve of which are now being installed. These transformers are of the oil immersed, water-cooled type, and are wound for 10,000, 11,000 and 12,000 volts primary and 60,000, 50,000 and 40,000 volts secondary. They will be connected in delta on both primary and secondary sides.

Each transformer is placed in a separate closed fireproof room, so as to minimize the fire risk and prevent the possibility of trouble in one transformer being communicated to others. The transformers are mounted on rails and arranged to slide out of the compartments into a gangway, where they can be readily handled by an overhead travelling crane. The piping for oil and water is placed in the basement under the back of the building and on the wall of the transformer compartments.

From the power house the cables are carried in ducts to a gallery above the transformers, where the 12,000-volt switches, instrument transformers and bus-bars are located. The high-potential bus-bars, wiring instrument transformers and air switches for the 60,000-volt circuits are located in the room back of the transformers, and connected through the gallery floor to the high-potential oil switches on the floor above.



WHEEL PIT AND BRANCH TAILRACE TUNNELS

The outgoing transmission lines leave the building through porcelain bushings at the back, and are protected by lightning arresters on the wall below.

The wiring throughout is completely enclosed in brick compartments, the only openings being through asbestos doors placed at points convenient for inspection.

The transmission line to Toronto, constructed by the Toronto and Niagara Power Company, is built on a private right of way 80 feet wide, which can later be used for a double-track railway. With this idea in view, the line was located so that the maximum grade at no point need exceed one per cent., and the minimum radius of track curvature can be made as low as a quarter of a mile.

Two complete steel tower transmission lines will eventually be constructed, one only being erected at present. Each tower carries two circuits of 190,000 c. m. copper conductor. The standard distance between poles is 400 feet, although much longer spans are used in crossing rivers and ravines. For curves and long spans special extra heavy towers are employed, with double and triple insulators. The height of the standard tower is sufficient to support the lower cable at a height of 40 feet from the ground. Fifty and 60-foot towers are made by bolting extensions to the bottom of the standard towers, and are used wherever there are depressions along the right of way. In two places towers 150 feet and 175 feet high are required in order to cross navigable channels at the Welland Canal and at Burlington Beach.

The copper cable consists of six strands with a hemp centre, and has a tensile strength of 60,000 pounds, and an elastic limit of 40,000 pounds per square inch. It was made by the Dominion Wire & Cable Company, of Montreal.

A large portion of the power is delivered to synchronous apparatus, the Toronto Street Railway employing rotary converters, and the Lighting Company synchronous motor-generator sets. The loss of power, when transmitting 10,000 H. P. to Toronto over each circuit, will be less than 10 per cent., and either line can transmit 20,000 H. P. with less than 20 per cent. loss should the other become disabled.

The insulators are 14 inches in diameter and 14 inches high, and are tested for a potential of 120,000 volts complete, or 60,000 volts on each of the three parts of which it is composed.

The transmission towers are heavily galvanized after all machine work upon the parts has been completed. They were made by the Canada Foundry Company, of Toronto, and the Riter-Conley Manufacturing Company, of Pittsburg, Pa. At points exposed to severe lightning the line will be protected by 12-foot extensions carrying galvanized steel cable above the power conductors.

There will be three division houses along the line, dividing it into four sections, any one of which can be cut out for inspection or repair. The length of the line is about 90 miles, and the division houses will, therefore, be 22½ miles apart. A lineman will control each section daily after the transmission is in operation.

The sub-station in Toronto is designed for fifteen 2670-KW. transformers, and is similar to the transformer house at Niagara Falls, except that there will be double low-tension bus-bars and a much larger number of feeder cables for distributing power throughout the city of Toronto.

The switchboard is located at one end for controlling the transmission lines, transformers and 12,000-volt circuits. This is equipped with dummy bus-bars with all necessary instruments.

In the plans of the Electrical Development Company every effort has been made to avoid any interruptions to the power service. No single accident or any probable combination of accidents is ever likely to shut down the entire plant. The double ice protection, twin tailrace tunnels, the extra 8000-KW. water-wheel, generator and transformer unit, and the duplication of the transmission lines and of all auxiliary apparatus is with this end in view.

The engineering design of the plant is in charge of Dr. F. S. Pearson as consulting engineer. The water-power development was planned by H. L. Cooper, chief hydraulic engineer, and the writer laid out the electric plant. The construction of the hydraulic work and power house was originally under Beverly R. Value, and is now in charge of L. J. Hirt as resident engineer, and Walter Pearson as electrical engineer.

The transformer houses and transmission line were built by Robert C. Brown, chief electrical engineer of the Toronto & Niagara Power Company.

The Columbus Convention of the American Street & Interurban Railway Association

According to the programme of the Columbus convention of the American Street & Interurban Railway Association and its affiliated associations, the various sessions will be as follows:—

Monday, October 15, Morning and Afternoon—Engineering Association, Claim Agents' Association.

Tuesday, October 16, Morning and Afternoon—Engineering Association, Accountants' Association, Claim Agents' Association.

Wednesday, October 17, Morning—First meeting of the "American" Association at which the members of the other associations will be present. Afternoon—Separate meetings of all of the associations.

Thursday, October 18, Morning and Afternoon—American Association, Accountants' Association.

Friday, October 19, Morning and Afternoon—American Association.

The committee on subjects has been actively engaged on the programmes of the four associations for several months past, and there is every prospect a number of interesting papers will be presented which will be of great value to the companies. While the programmes of the various associations are practically complete, it is expected that a later bulletin will show several additional papers bearing upon subjects of more than usual interest.

A partial list of the papers to be read before the American Street & Interurban Railway Association follows:—

"Elevated Railways and Their Bearing on Heavy Electric Traction," by H. M. Brinckerhoff, of New York.

"Electric Railways in Sparsely Settled Communities," by E. P. Roberts, of the Roberts & Abbott Company, of Cleveland, Ohio.

"Interurban Limited Trains," by H. P. Clegg, president of the Dayton & Troy Electric Railway Company, of Dayton, Ohio.

"Interurban Freight and Express," by E. C. Spring, general manager of the Dayton, Covington & Piqua Traction Company, of West Milton, Ohio.

Reports are to be made on municipal ownership and on public relations.

At the meeting of the Accountants' Association, a paper on "Depreciation as Applicable to Electric Railways" is to be read by R. N. Wallis, treasurer of the Fitchburg & Leominster Street Railway Company, of Fitchburg, Mass.

Before the American Street & Interurban Railway Engineering Association, the following papers are to be read:—

"Ballast," by Chas. H. Clark, engineer, maintenance of way of the Cleveland Electric Railway Company, of Cleveland, Ohio.

"Gas Engines," by Paul Winsor, chief engineer, motive power and rolling stock of the Boston Elevated Railway Company, of Boston, Mass.

"Economy of Car Equipment, Weights and Schedules," by E. H. Anderson, of Schenectady, N. Y.

"Ties, Poles and Posts," by C. A. Alderman, chief engineer, the Cincinnati Traction Company, of Cincinnati, Ohio.

"Underground Cables," by H. G. Stott, superintendent of motive power, the Interborough Rapid Transit Company, of New York.

The new low-grade freight line of the Pennsylvania from Harrisburg to Atglen will be operated by telephone.

An Interesting Case of Electrolysis

By SAMUEL H. McLEARY, M. E.

WHILE in Porto Rico early this year, the writer had occasion to investigate a very interesting phenomenon manifesting itself on the track of a certain electric railway. It had been observed that the rails at various points of the road were apparently wearing away very rapidly where they were in contact with the spikes. This wear had been so persistent that additional spikes had to be driven to retain the rails in place. In fact, it was found that many old spikes were not even in contact with the rails, but were merely standing in recesses formed in the flanges of the rails. In many cases new recesses formed in the rails adjacent to the new spikes driven in beside the old ones.

Three suggestions were offered in explanation of this peculiar occurrence: that frictional wear occurred between the rail and spike; that frictional wear was augmented by the cinder ballast used; that electrolysis was occurring between the rail and the spike.

FIG. 1.—A RAILROAD SPIKE HEAVILY INCRUSTED BY ELECTROLYTIC ACTION. AROUND THE HEAD OF THE SPIKE THE RAIL FLANGE WAS ALSO ATTACKED

The first reason will hardly hold. The wear shown by old rails used on the same roadbed during the fifteen years preceding electrification was characterized by much shallower recesses than those produced in larger, heavier rails used for only four or five years, with electric traction. The cinder ballast, while perhaps assisting this erosive action, nevertheless was not of prime importance, for some of the most prominent evidences of the trouble were present where cinder ballast had not been used.

FIG. 2.—BETWEEN THE SPIKE SHOWN NEAR THE CENTER OF THE ILLUSTRATION AND THE RAIL FLANGE A HEAVY INCRUSTATION HAS FORMED

FIG. 3.—ANOTHER SPIKE HEAVILY INCRUSTED BY ELECTROLYTIC ACTION

The third suggestion seems to be undoubtedly the true reason. The fact that for fifteen or twenty years of steam traffic 45-lb rails showed less erosion than 70-lb rails used only four or five years with electric traction, naturally leads one to the conclusion that electricity must be an important factor in the trouble. Accordingly, it was arranged to make tests to determine the cause of the erosion, and although an accident prevented anything from being done along this line—at least at that time—several photographs of interest were secured.

Wherever the most prominent examples of this peculiar erosion were found, tests showed the spikes to be electro-negative with respect to the rail—in most cases markedly so. At such points, the spikes were found to be heavily incrusted with a brittle metallic-looking deposit, the incrustation sometimes doubling the size of the head of the spike.

In Fig. 1 is seen such a spike heavily incrusted. Around this spike a very deep semi-circular recess was formed in the 70-lb. rail. The edge of this cut was entirely free from the spike, though almost surrounding it.

Fig. 2 shows another electrolytic deposit between the spike and the flange of the rail. This causes the spike to appear very much larger than the others shown in the illustration, though they are all actually the same size. Fig. 3 shows another form of incrustation.

FIG. 4.—THE BOTTOM OF THE FLANGE OF A 45-POUND RAIL, SHOWING THE GREAT EXTENT OF DAMAGE BY ELECTROLYTIC ACTION

In Fig. 5, the deep recess in the rail is clearly shown. It will be observed that the spike has been moved to the edge of the tie, where the rail is sound.

Fig. 4 is one of the most interesting of all. It is a view of the base of an old 45-lb. rail, and clearly shows the difference between excessive frictional wear and the electrolytic action. It will be observed that this electrolysis has so completely eroded both sides of the rail flange that a crack has actually been started. The rail flange, in addition, has a bluish, glazed appearance, as if it

4-5

had been subjected to a considerable heat. Such an effect is frequently produced by electrolytic action. The clearly outlined semi-circular cut in the lower edge of the flange is slightly larger than the spike that formerly rested in there, and is too sharply defined to have been produced by any movement of the rail. The various indentations on the lower side of the rail-base are due to ordinary

FIG. 5.—IN THIS CASE THE RAIL FLANGE WAS EATEN ENTIRELY THROUGH. THE SPIKE SHOWN IS A NEW ONE, PLACED FURTHER ALONG ON THE EDGE OF THE TIE

frictional wear, and are seen to differ materially from the electrolytic erosions shown in the figure.

The track bonding of the worst sections of the road was in need of repair at that time. The moist climate and frequent rains, in conjunction with the defective bonds, are probably the cause of this unusual electrolysis. With good bonds, well-drained roadbeds, and sound ties, the trouble can probably be eliminated entirely.

This electrolytic phenomenon has apparently been overlooked, and as it seems to be a factor in the life of a rail, it is to be hoped that it may be the subject of a further investigation. It will at least serve to indicate one additional reason for good bonding.

Some interesting figures regarding the use of electrically ozonized air in removing bacteria from water are given in a letter addressed to the Commissioner of Public Works of Philadelphia by W. W. Gibbs, president of the United Water Improvement Company. Tests were made on water drawn from the Schuylkill River containing 2,500,000 bacteria per cubic centimeter. After being roughly strained to remove the larger particles of suspended matter, the same amount of water was found to contain from 253,000 to 700,000 bacteria. After the ozonized air was passed through the water the bacteria were reduced to from 5 to 55. About 200 kilowatt-hours are required for each million gallons of water.

An Exposition of Safety Devices

THE American Institute of Social Service will hold in New York City, in January next, an exposition of devices for safeguarding the lives and limbs of working men and women, and for preventing accidents under the ordinary conditions of life and labour to which the general public is exposed. This will be the first exposition of the kind in the country.

In 1889 there was a German exposition for the prevention of accidents. In 1893 an exposition of this nature was held in Amsterdam, and since then there have been several similar expositions in Continental Europe and in Canada. As an outgrowth of these national movements there have been organized several museums of security,—one at Vienna in 1890, one at Amsterdam in 1893, one at Munich in 1900, one at Berlin in 1901, and one at Paris in 1905, and Russia has recently established a museum on a large scale at Moscow.

Following are some of the groups of exhibits:—Section 1, models, photographs and drawings of scaffolding, as well as the personal equipment of workers in building trades.

Section 2, protective devices for boilers, water gauges, signal apparatus, boiler and pipe valves, protective devices for electrical machinery and acetylene apparatus.

Section 3, protective devices for motors and power transmitters, devices for turning on power and shutting it off, belt connection, coupling, etc.

Section 4, fire protection and the prevention of explosion.

Section 5, first aid to the injured.

Section 6, mining and quarrying, devices in use on stone crushing machinery, etc.; storing of explosives.

Section 7, metal industry, safety devices for metal-working machinery.

Section 8, textile industry, safety devices for looms, carding, etc.

Section 9, leather and paper industry, safety devices for paper cutting, stamping and moulding machinery.

Section 10, safety appliances for elevators and hoisting apparatus models.

Section 11, food products, safety appliances for kneading machines, rollers and cutters.

Section 12, personal equipment of workingmen, protective spectacles, respirators, suits, etc.

Section 13, workingmen's dwellings.

Sections 14 and 15, housing models, plans, photographs.

Section 16, ventilation.

Section 17, models, photographs and plans of toilets, dressing and living rooms, baths, etc.

Section 18, cooking demonstration in heating food, models, plans, photographs.

Section 19, other social betterment institutions, reports of labour departments, industrial arbitration courts.

Section 20, agricultural machinery, safety appliances on same, demonstrated by models and views.

Section 21, lumber industry, safety devices for band and circular saws, planing machinery, etc., demonstrated by models.

Section 22, models, photographs and plans of workingmen's industrial betterment institutions of all kinds.

Requests for information regarding space can be made to Dr. William H. Tolman, director, 287 Fourth avenue, New York.

A Mountain Telephone Line

AN interesting telephone line has recently been erected on Greylock Mountain, Adams, Mass. The line is built on poles to the base of the mountain, where the wires then run through a 1-inch steel pipe. The pipe is strapped to the solid rock in the centre of a large landslip that occurred some years ago. The steel straps are riveted to the rock, holes having been drilled for that purpose. There are 2800 feet of wire in the pipe.

At the top of the landslip the wires come out of the pipe and are strung on poles to the summit. The poles used on top were cut there, and are of spruce. Some of them are set in 6 feet of solid rock.

In the pipe that is on the slide, hand holes are spaced 300 feet apart to permit of repairs.

To provide earth wires against lightning, two poles at the base of the fallen rock are set in 8 feet of water, and about 50 feet of wire is coiled about to take the discharge of the lightning should it attack the line. Mountain climbers are warned against using the pipe in climbing, especially during thunder showers, when they might receive fatal shocks.

In the ten years ending December 1, 1905, the toll and long-distance service of the American Telephone & Telegraph Company and its subsidiary companies has increased from $4,000,000 to $30,000,000. In the same time the service of the Western Union Telegraph Company has increased only from $22,218,019 to $29,033,635, due to the competition of the Postal Telegraph-Cable Company.

From the World's Technical Press

The Internal Cleaning of Electrical Machinery

NEXT to the lubrication of rubbing surfaces, which is generally of the simplest nature possible, says "The Electrical Review," of London, cleaning electrical machinery is the most important consideration, particularly with regard to internal regions, where heat is most likely to affect any matter present.

A large proportion of electrical machinery, generators, motors, rheostats and the like is of such construction that the interior is not accessible for the removal of the ubiquitous matter out of place by the direct application of the usual agents, namely, rags and waste, which suit the purpose so far as the exterior is concerned. In order to meet the necessities of the case air is pressed, or rather compressed, into service, with the result that cleaning can be thoroughly accomplished by a jet of air under a pressure of some 20 or more pounds per square inch above the atmospheric pressure.

When the amount of cleaning to be done is small, as in the case of an installation of one or two motors of some 10 or 20 horse-power, a pair of hand bellows energetically applied once or twice a week will prove amply sufficient for the purpose; but where the machines are many or of larger size, a more powerful and sustained source of air-blast must be utilized to obtain the utmost expedition. As an example of the latter case may be taken any electric generating station with more than four or five generators, where it is desired so to arrange the duties of a limited staff that they can do multifarious tasks as readily as possible.

It is found that if an air compressor is installed with a suitable system of piping, the machinery can be kept in a more satisfactory state with one-quarter the time, and less than that proportion of human energy that will be required if a pair of bellows is applied to each machine with the necessary intervals of rest between.

A suitable equipment of the kind for a central station consists of an air compressor driven by a motor or engine, of about ½ H. P., fixed in the machinery room with a 1-inch main air pipe under the floor in connection with a cylindrical reservoir of about 3 cubic feet capacity. From the main pipe a ¾-inch branch with a valve, just above floor level, is taken up to each generator with a pipe terminal to which may be attached a flexible hose of the length necessary to reach all parts of the machine. The hose should be of the kind protected by wire, and may suitably terminate at the "business" end in 6 inches of ¾-inch brass tube hammered flat at the point to make a slit-like orifice 1 inch x 1-16 inch, this shape enabling it to be presented more effectually than a circular nozzle between armature windings.

To take a different case, where the machinery to be operated on consists of many motors in different parts of a building, as in a tramway car-shed, a portable electrically-driven air compressor, with flexible leads and pipe, is a more useful apparatus.

The Electric Welding of Automobile Parts

IN the past ten years, says W. S. Gorton in "Motor Traffic," the necessity for complex metal parts in the construction of the bicycle and the automobile more especially, has provoked a new field for the use of electric welding. It is safe to assert that there is not a single automobile of American manufacture in use to-day which has not several of the iron or steel parts, forming a part of the structure of this apparatus, electrically welded.

In the early days—five years or more ago—the rims of the steel supports for the rubber tires were the only parts which were manufactured by this process, and the same parts are electrically welded to-day. Since that time the gradual development of the business has made the application of electric welding cover a very much wider range, so that the present vehicle may have from four to twenty parts so united.

I-beam axles, which are much used in the construction of automobiles, are generally welded in this way. Thousands of different parts formed of drop forgings or steel castings, such as steering levers, universal joint shafts, tubular transmission shafts, body loops, connecting rods, tubing, exhaust and intake valves, and hubs, are welded in a way that it would be impossible to do in the forge, and a product is the result that is far superior even to the solid drop forgings. This is explained by the fact that in many pieces it is necessary to have metals of two different types to form one satisfactory complete article, and electric welding renders valuable aid in effecting the junction.

The steel stamping is in many places superseding the drop forging, and in connection with this electric welding is aiding, and will in the future to a greater extent than at present aid, the manufacturer and benefit the user of automobiles. With the gradual adoption of well-tried devices, so that the construction of the motor car becomes less complex and more uniform, and as the business will surely become more centralized owing to its special nature, by manufacturers producing in larger quantities than at the present time, it is safe to predict that every large concern will have one or more of these welding machines installed in their works, forming a regular part of the equipment, the same as any machine tool of the present day.

The adaptation of this interesting

method of welding in the automobile line has only just begun. The manufacturer is just appreciating the value of this method as a time and money saver.

Motor-Driven Ice-Handling Machinery

THE advantages of driving ice-handling machinery by electric motors are apparent at first glance, says "Ice and Refrigeration." The source of power can be located much nearer the tower machinery of the elevator. It is compact, of small weight, and can be placed where other sources of power could not be supported. The electric motor is noiseless and cleanly in operation. If proper judgment is exercised in the selection of sizes and of voltages to operate the motor, there need be no more danger of fire than in the ordinary steam-driven plant.

Once installed, an electrically operated plant does not require skilled help for the power end during the harvesting season, and the motor may oftentimes be located sufficiently near the top of the tower so that the friction tender can give it any necessary attention, thus dispensing with the services of an engineer or a fireman, or both. A motor-driven elevator can be instantly started and operated continuously and evenly, whereas in a steam-driven plant it is often necessary that the engineer be on hand very early, so as to have steam available at 7 o'clock, and if tne weather is exceedingly cold extra help must be employed to tend the fires during the night.

The Discovery of the Mariner's Compass

THE discovery of the mariner's compass is discussed in an extract from a magazine published seventy years ago, and given in a recent issue of "The Electrical Engineer," of London, as follows:—

"Much interest must forever attach to the discovery of this instrument, and yet there are few subjects concerning which less is known. For a period the honour of the invention was ascribed to Gioia, a pilot or ship captain born at Pasitano, a small village situated near Malphi, or Amalfi, about the end of the thirteenth century. His claims, however, have been disputed.

"According to some, he did not invent, but improved it, and according to others he did neither. Much learning and labour have been bestowed upon the subject of the discovery. It has been maintained by one class that even the Phœnicians were the inventors; by another that the Greeks and Romans had a knowledge of it. Such notions, however, have been completely refuted.

"One passage, nevertheless, of a very remarkable character occurs in the work of Cardinal de Vitty, Bishop of Ptolemais, in Syria. He went to Palestine during the fourth crusade, about the year 1204; he returned afterwards to Europe, and subsequently went back to the Holy Land, where he wrote his work entitled 'Historia Orientalis,' as nearly as can be determined, between the years 1215 and 1220. In chapter XCI. of that work he has this singular passage: 'The iron needle, after contact with the lodestone, constantly turns to the north star, which, as the axis of the firmament, remains immovable, whilst the others revolve, and hence it is essentially necessary to those navigating on the ocean.' These words are as explicit as they are extraordinary; they state a fact and announce a use.

"The thing, therefore, which essentially constitutes the compass must have been known long before the birth of Gioia. In addition to this fact, there is another equally fatal to his claims as the original discoverer. It is now settled beyond a doubt that the Chinese were acquainted with the compass long before the Europeans. It is certain that there are allusions to the magnetic needle in the traditionary period of Chinese history, about 2600 years before Christ; and a still more credible account of it is found in the reign of Chingwang, of the Chow dynasty, before Christ 1114.

"All this, however, may be granted, without in the least impairing the just claims of Gioia to the gratitude of mankind. The truth appears to be this: the position of Gioia in relation to the compass was precisely that of Watt in relation to the steam engine—the element existed, he augmented its utility.

"The compass used by the mariners of the Mediterranean during the twelfth and thirteenth centuries was a very uncertain and unsatisfactory apparatus. It consisted only of a magnetic needle floating in a vase or basin by means of two straws or a bit of cork supporting it on the surface of the water. The compass used by the Arabians in the thirteenth century was an instrument of exactly the same description.

"The inconvenience and inefficiency of such an apparatus are obvious; the agitation of the ocean, and the tossing of the vessel, might render it useless in a moment. But Gioia placed the magnetized needle on a pivot, which permits it to turn to all sides with facility. Afterwards it was attached to a card, divided into thirty-two points, called Rose de Vents, and then the box containing it was suspended in such a manner that, however the vessel might be tossed, it would always remain horizontal.

"The result of an investigation participated in by men of various nations, and possessing the highest degree of competency, may thus be stated. The discovery of the directive virtue of the magnet was made anterior to the time of Gioia. Before that period, navigators, both in the Mediterranean and Indian seas, employed the magnetic needle, but Gioia, by his valuable improvement in the principle of suspension, is fully entitled to the honor of being considered the real inventor, in Europe, of the compass as it now exists."

Oils for High-Tension Switches

THE results of tests of oils used for high-tension oil-break switches are given by J. H. Bolam in a recent issue of the London "Electrician." The method of testing consisted in determining the break-down point of thin layers of oil between small terminals. Current was obtained from an alternator, the voltage being stepped up by a transformer.

The requisites of an oil suitable for the use indicated are as follows:—It should have a high insulation resistance; it should be capable of quickly extinguishing the arc; it should be free from acids or other compounds liable to corrode the switches; it should not gum; it should be as fluid as is consistent with a quick extinguishing of the arc; it should have a high flash point, and it should be transparent.

When pure, nearly all oils are good insulators, but the action of an arc alters this aspect, as some of the oils are decomposed. Castor oil has a high insulating value, but it does not extinguish the arc. For switch work, mineral or resin oil is generally used, although the latter has fallen into disfavour lately. The insulation properties of the two oils are similar, the resin oil perhaps having a slight advantage.

As a general thing, mineral oil should be used, because, in the preparation of vegetable and animal oils, chemicals must be used which are apt to leave undesirable materials in the oil. Tests show that the highest insulation resistance was given by a resin oil. Then follow several mineral oils, the one having the lowest flash point being the best.

An ordinary mineral engine oil gave fairly good results, the breakdown voltage being 18,000 for a spark-gap one-sixth of an inch. The resin oil, with the same spark-gap, required a breakdown voltage of 32,000. This resin oil gave in every way the most satisfactory results of all the oils tested.

Metallic Filaments for Electric Lamps

IT is now quite well known, says J. Swinburne, in the London "Times" Engineering Supplement, that several metals are infusible enough to serve as lamp filaments if they can only be made into that form. The infusibility of the metal is the chief obstacle to its being made into wire, for such metals are generally obtainable only in a fine powder by reduction from the oxide, or in partially fused lumps which contain carbon, and are not in a condition suitable for wire drawing.

Dr. Hans Kuzel has invented a process by which the most refractory and obstinate metals can be made into filaments. It might be said that there is little difficulty in making a filament from a metallic powder by mixing it with an agglutinant and squirting it. Anyone who has tried squirting such things as powdered silicon, tungsten, or molybdenum, will realize the difficulties. Tungsten powder, for instance, can be squirted in rods about a millimeter in diameter; but these would be of no use for resistances in thousands of ohms. These powders, made into pastes and squirted, generally pack, and only water comes through the nozzle. Squirting can be greatly facilitated by the use of gum tragacanth. It would be interesting to know who first thought of tragacanth in that connection. A comparatively small percentage of the population of the globe knows anything about tragacanth or its ways; and a still smaller percentage is interested in squirting filaments; so that the chances that any one person, knowing about tragacanth and wanting to squirt filaments, should realize that tragacanth would help him are very small indeed. I believe the use of this gum was due to Farnejehlm,—one of the early workers in incandescent gas light. He made mantles of little baskets of squirted magnesia.

Kuzel is generally supposed to have invented a tungsten lamp. His invention is really a method of making lamp filaments of any suitable metal; and he appears to have chosen tungsten as the most suitable. He has invented a most ingenious way of converting metals into a fine, smooth paste, in which the particles are so exceedingly small that very fine filaments of paste can be squirted. These filaments are then heated electrically until they practically fuse together.

If this invention works practically, as there is little doubt it does, it opens a very large field, because it puts the inventor in the position of being able to make lamp filaments of any metal he chooses. It is simply a matter of choosing one which has a high melting point, and is otherwise convenient. Of course, the melting points of the very refractory metals are not yet ascertained. It has been known for a long time that tungsten is very infusible; and it was considered an achievement when it was first fused in the electric furnace some fifty years ago. The metal is otherwise so unpromising physically that to make from it a lamp filament is a very remarkable triumph over the apparent obstinacy of inanimate things.

The Effect of Smoke on Trolley Wire in Joint Operation

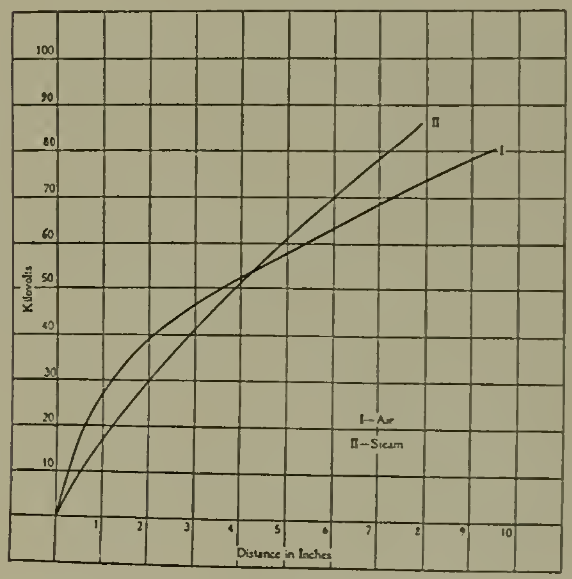
MANY proposals are now under way for the joint operation of electric cars and steam locomotives on the same tracks, and the question has arisen as to whether if high-voltage trolley wires are placed over the tracks, and particularly at such places as in tunnels and under bridges, there might be dielectric discharges from the trolley to the locomotives and ground caused by the steam and smoke of passing locomotives acting as conducting mediums.

To determine the likelihood of trouble under these conditions, a series of tests described by S. M. Kintner in "The Electric Journal," were carried out with two terminals placed one above the other and arranged so that the space between them forming the discharge gap could be varied. The terminals were ½ inch in diameter with spherical ends, and were so mounted that jets of steam and smoke could be projected around them in a direction parallel to their axis of support.

In the first test a column of steam was projected across the gap between the two terminals. The steam was purposely made very moist by passing it through a long line of pipe, so that it lost a large quantity of heat before arriving at the gap. The results of this tests are shown in the curves in the accompanying diagram.

It will be seen that the striking distance, or distance at which current will jump the gap, is greater for a given voltage in air than in smoke for voltages below approximately 55,000, but that at this point the curves cross each other, and it requires a greater voltage to jump a given gap in steam than in dry air.

The jumping distance in air, as plotted in this curve, was obtained by measurements taken at the time the curve for steam was determined, the same terminals being used and the points checked several times, so



GRAPHIC REPRESENTATION OF TESTS TO DETERMINE THE RELATIVE TENDENCIES TO DIELECTRIC DISCHARGES IN ORDINARY AIR, IN STEAM, AND IN SMOKE

that it seems certain that the values are relatively correct. During the test with steam the terminals were saturated with moisture to such an extent that the water dripped from them freely. No perceptible change was noted, however, when the steam was somewhat drier.

The next test was made to determine the conductivity of smoke and cinders. The terminals were immersed in a dense volume of smoke produced by building an intense fire in a small stove. After a hot bed of coals was obtained, some fresh coal, containing considerable dirt, sulphur, etc., was thrown on the fire to prevent perfect combustion and produced large quantities of very dense black smoke. It was in this case impossible to maintain constant conditions through a sufficient period to obtain a curve, but a number of observations were taken which indicated that the striking or jumping distance through dense smoke was not materially reduced from that of the steam or air in the previous test.

One set of readings was as follows:—

TABLE OF VOLTAGE-STRIKING DISTANCES IN DENSE SMOKE AND STEAM

Voltage	Distance in Inches
14,000	1.375
25,000	2
35,000	3
42,000	3.75

From these tests the conclusion is made that with a reasonable factor of safety, of possible six or seven, over the dielectric strength of air, no difficulty will be encountered through steam and smoke from locomotives attracting current from an overhead trolley wire.

Using Exhaust Gases in a Gas Producer

THE results of tests of a gas engine operated with a suction gas producer, in which a part of the inert gases from the engine were used instead of steam, are given by George H. Barrus in a recent issue of "Cassier's Magazine." When the exhaust gases were used in the producer, the clearance was reduced by attaching special cylinder heads, which extended into the bore of the cylinders a distance of 1 inch (the face of the standard head being flush), thereby increasing the compression to the neighbourhood of 200 pounds.

The reason for changing the clearance of the engine when using the exhaust gases in the producer will be best understood by considering the effect which they have on the composition of the original gas. The principal combustible elements which the gas contains when steam is used in the producer are carbonic oxide and hydrogen. The effect of shutting off the steam is to remove most of the hydrogen, and leave carbonic oxide alone as the leading combustible element of the product. The substitution of a part of the exhaust gases in place of the steam, it should be said, has the same cooling effect on the fire, and the same effect in preventing fusion of the ash and the formation of clinkers, as the steam has, and is a necessary condition for the continuous operation of the producer without it.

The presence of hydrogen in the gas stands in the way of securing more than a limited degree of compression in the engine cylinders. When that limit is passed, the hydrogen is ignited by the heat formed during compression, and the objectionable features known as "backfiring" and "pre-ignition" occur. With carbonic oxide alone as the principal combustible element, the engine is enabled to carry a much higher degree of compression, and thereby produce a proportionately greater amount of power. Consequently, on the tests using exhaust gases, the clearance in the engine was reduced so as to obtain the benefit which might follow the increased compression due to that change. No experiments were made to see if the best point of compression was reached, but all the indications seem to be that a further increase would have resulted beneficially.

The results of tests using the exhaust gases and others using steam are given in the following table:—

LEADING DATA AND RESULTS OF ECONOMY TESTS

Conditions	Exhaust Gases Used	Ordinary System
Date of test, 1906	March 28-29	April 5-6
1. Duration, hours	25.5	14.05
2. Total time engine was running, hours	25.5	13.17
3. Maximum brake horse-power developed	110.5	99.8
4. Minimum power developed, horse-power	50.	7.6
5. Average brake horse-power developed for entire period	102.5	78.7
6. Average brake horse-power for running period	102.5	84.1
7. Total weight of dry coal consumed, pounds	2,927.	1,988.
8. Total ash and refuse, pounds	391.	317.
9. Percentage of ash and refuse in dry coal	13 5	15.9
10. Weight of dry coal per hour, pounds	114.8	141.5
11. Dry coal consumed per brake horse-power per hour (line 5), pounds	1.12	1.8
12. Combustible consumed per brake horse-power per hour, pounds	.97	1.51

Single-Phase Motors

POLYPHASE motors have many advocates, writes L. J. Pumphrey, in "The Electrical Review," of London, and have done excellent service in connection with the driving of factories and machinery. At the same time, difficulties in connection with speed regulation and the necessity for three connecting wires are drawbacks, and there will, therefore, be a very great field of utility for single-phase motors. The latter may be roughly divided into (1) motors with constant magnetic field; and (2) motors with alternating magnetic field. In Class 1 we have simply an ordinary alternator used as a motor, which is usually known as a synchronous motor. Owing to the fact that these are not self-starting, they are practically of little value for commercial purposes, except when rqeuired to drive very large loads and to run practically continuously.

An over-excited synchronous motor produces a leading current, and, therefore, from the point of view of power factor, it is a great advantage to have motors of this type connected on a supply system. Owing to their absolutely constant speed and high efficiency, they are frequently used for driving dynamos and line shafting. In some cases amortisseur circuits have been fitted to the magnet poles, and these prove of great advantage in assisting the motor to keep in step when overloaded.

Passing now to the second class—viz., motors with alternating magnetic field—we find that development of these has taken place along various lines. Broadly speaking, they may be divided into the following types:—(1) Pure induction motors; (2) series motors; (3) repulsion motors; and in addition there have been designed various combinations of these classes. Pure single-phase induction motors have been very largely used for many classes of industrial work, but these are inefficient, as compared with three-phase motors, and their starting performance is extremely poor. Economical running is only obtained over a small portion of the total speed range.

Recently the alternating-current series motor has been attracting a great deal of attention, and is now on the market. It has been built in small sizes for some time past, but it is only quite lately that commutation difficulties have been sufficiently overcome to make it a practical success in large sizes. On account of its variable speed, however, it is not well adapted for most stationary work, and its sphere of usefulness will probably be confined to railways and cranes, where the direct-current series motor at present holds the field. One advantage of the motor, of course, is that it will operate on either direct or alternating current, and it is found experimentally that it has practically the same characteristic when running on either system of supply.

The various modifications of the repulsion motor are, at present, attracting a great deal of attention, for it is this type that seems most nearly to approach the results that are obtained with direct-current shunt motors, i. e., it has an excellent starting torque and a constant normal speed. The pure repulsion motor is practically useless, owing to its poor running performance, but by connecting it as an induction motor when it is running up to speed, excellent results have been obtained.

Single-phase repulsion induction motors can be started from a distance by simply closing either the primary or secondary circuit, and they are thus specially adapted for pumping work, air compressors or similar machines, arranged to be started and stopped by means of a float-switch or pressure regulator. When connected directly across the lines, a motor of this type will develop two and one-half times full-load torque at starting with two and one-half times full-load current, but by the time the motor has reached quarter speed, the torque will have increased to five times full-load torque, and the current decreased to double-load current. Both torque and current may be materially reduced by altering the relative position of the brushes and the field.

Some Points About Fuses

ONE of the principal features of the fuse, says "The Electric Journal," is its overload time element. Before a given current will heat up the fuse metal to its melting temperature a fixed time must elapse. This time lag, as it is commonly called, rapidly decreases as the current increases.

There is a common impression that fuses and overload circuit breakers have practically the same characteristics, though such is not the case. The overload circuit breaker depends for its operation upon the quantity of current, while the blowing of a fuse is dependent both upon the quantity of current and upon the time during which it is applied. The circuit breaker will open immediately at any overload in excess of its setting, but will not operate at any smaller current, no matter how long continued. Standard fuses, on the other hand, will operate, in time, at as small an overload as 25 per cent., and will open in a proportionately shorter time with greater overloads.

In determining the proper size of fuses to protect any apparatus, the overload time element should be considered in connection with the smallest current likely to prove dangerous. The low cost and the overload time element of the fuse render it particularly suitable for the protection of motor circuits, as it will carry a certain overload for a short time, but will open if the overload continues.

For alternating-current motors, taking a starting current much more than the full-load value, fuses which would carry the starting current would not give much protection except against a short-circuit. In order, therefore, to afford adequate protection, a second set of fuses is necessary. These fuses should be switched into the circuit after the motor has come up to speed. When thus used they may be of suitable capacity to give much better protection to the motor.

The use of two enclosed fuses in parallel is not advisable unless sufficient resistance is placed directly in series with each fuse to render the contact resistance of the fuse negligible. Fuses have such low resistance that equal resistances in the two branches cannot be insured except by the arrangement just mentioned, as the resistance of the contacts would be proportionately large. When branches of unequal resistance are in parallel the two fuses do not carry equal currents, and are likely to open the main circuit at a current less than their combined carrying capacity.

High-Tension, Direct-Current Electric Power Supply for Paris

SOME details of a project for transmitting high-tension direct current from the Rhone River to Paris are given in a recent number of the London "Electrician." The point in the river from which the water supply would be obtained is near its entry into French territory near Bellegrade and about 250 miles from Paris in a straight line.

A minimum supply of 80,000 H.P. is available, with a maximum of nearly double that amount during 300 days of the year. An artificial lake in the plain of Collogny could serve as a storage reservoir.

In the power house 48 direct-current series-wound generators would each deliver 1000 amperes at 2500 volts, making the line voltage 120,000. The generators would be divided into two groups, each group being driven by eight 10,000-H. P. turbines. Three generators would thus be driven by one generator.

The central point of the generating system would be earthed so that the difference of potential between the earth and the line would be 60,000 volts. As the load lessened, the voltage would be cut down by cutting out the generators not required, the current, however, being maintained at 1000 amperes.

In Paris, the receiving stations would be equipped with a similar series of motors, the central point also being earthed. In this way, if one-half of the system should break down, the other half could still remain in operation. The two transmission lines would run over separate routes, towns being avoided as far as possible. It is estimated that power could be delivered at the receiving stations for 0.6 cent to 0.8 cent a kilowatt-hour.

The Utilization of Small Water-Powers

ENGINEERS in the East, says "The Engineering Record," have been so long accustomed to thinking of a water-power as something with a big dam across an imposing stream that the possibilities of a small stream under the high heads of a mountainous region may be overlooked by them. At, say, 20 feet of head, it takes a wheel a couple of feet in diameter and a flow of nearly 3500 cubic feet of water per minute to give 100 H. P. At 75 feet head a 10-inch wheel will do the same work on about 850 cubic feet per minute, and when several hundred feet are obtainable the water demanded is proportionately less, until at 650 feet of head a mechanical horse-power corresponds to a cubic foot per minute. A mere brook then suffices to give a power that may be worth at least developing for local use.

The general cost of development and equipment tells part of the story, the cost of transmission the rest. In the hydraulic work the cost of conduits from the dam to the power house is generally the controlling item when considering high head, and this is again determined by the distance necessary to be covered. If the cost can be kept in the neighbourhood of $100 per horse-power, the outlook for an economical short transmission is good, since this means an annual charge of no more than $10 or $12 per horse-power for the motive power.

The cost of wheels and generators with their equipment will commonly run from $25 to $30 per kilowatt in cases where raising transformers are not needed, the usual case for small powers. All of this can be approximated very readily, as also can the cost of the necessary buildings. The heaviest charges in small work come in the operating expenses and in the pole line. Pole lines for light wires need not cost more than $250 to $300 per mile, exclusive of wires and right of way.

For mechanical reasons, however, it is not desirable to string wire smaller than No. 4 or No. 5, so that the minimum cost of conductor is somewhere about $500 per mile. Fortunately, the depreciation charge against bare wire is practically negligible, and wire of this minimum size will carry comfortably the output of the class of plant considered.

The cost of attendance is the most serious output in small stations. It means generally the pay of at least three men, and occasional extras, not less than $2000 per year even for a very small plant. At 100-KW. capacity this would come to at least $20 per kilowatt per year, which, added to the other charges, is pretty nearly prohibitive. At 200-KW. capacity the operating charge gets down to reasonable figures.

In a rough estimate one will not go far wrong in saying that for electrical purposes a water-power of 250 to 300 H. P. on steady flow is worth considering. Anything below this is of little account except for local utilization, and the usefulness of the power increases rapidly above this point. If the situation is favourable for storage, a good deal can be done with small streams, but unless the above amount can be made available without going to heavy expense, there is not much that can be done. If several such powers are available they can be often worked together to advantage.

Electrical Production of Steel in Sweden

A STOCKHOLM correspondent of "The Electrical Review," of London, writes that Swedish capitalists and manufacturers have submitted a scheme to the government, which aims at the electrical production of steel according to the process devised by Messrs. Grondal & Kjellin. The proposal is to form a company to erect works in the district of Goteborg and on Norrland, provided that the government will utilize the waterfalls in the vicinity and supply the power to the company.

In the case of the projected works near Goteborg the intention is to produce 500,000 tons of iron and steel per annum by means of electrical energy supplied by the utilization of the Trollhatta waterfall, and a similar tonnage is foreshadowed for the works on Norrland. It is pointed out that an annual output of 1,000,000 tons of steel would not only meet the inland demand in respect of steel for warships and guns, and for railway rails, joints, etc., but it would also permit of the creation of a large export trade, owing to the low cost of production by means of water-power and the cheapness of labour.

The government, after due consideration, has agreed to the proposal. The company is to bear the title of the Metallurgiska Patent Aktiebolaget, and it has already been settled that the Trollhatta falls shall be brought into use for the purpose in view. It is assumed that the undertaking will have about 15,000 H. P. at its disposal in 1908. The F. Krupp Company is understood to have purchased the rights to work the process in Germany, while Messrs. Vickers, Sons & Maxim are credited with the possession of the same privilege for England.

Electricity in Afghanistan

AFGHANISTAN, says "The Electrical Engineer," of London, is primarily associated in people's minds with native risings and repressions rather than with industrial activity. But this Asiatic province, which is a veritable pawn on the political chessboard, is not altogether without its quota of commercial enterprise. The Ameer, who has literally created the new town of Jabl-us-Siraj, is deeply interesting himself in its development. He has determined to employ electric power in his factories, but the cost of fuel is so high that the driving of dynamos by steam would involve heavy expenditure. There is, however, an enormous amount of water-power running to waste in the Khoistan, and this is now to be utilized. At Jabl-us-Siraj, apparently, the Panjshehr has a sufficient fall to give all the power that is needed, and the necessary works are being undertaken to utilize this. An electrical engineer has been engaged, and machinery will be erected in due course. It is believed that the arms and ammunition factories will be eventually transferred to the new town, and it is probable that manufacturing industries may be started as well.

Electricity in the Rolling Mill

BLOOMING MILLS require a prime mover to be self-starting and reversing, and all types demand enormous overload capacity. Electric motors receiving current from generators direct connected to gas engines appear to have, in combination, possibilities which are far beyond anything achieved by the older methods of engine drive. Electric motors are now used to drive "three-high" rolling mills with entire satisfaction, compound-wound motors being perfectly adapted to the widely varying character of the load and the requirement for roughly uniform speed between the violent momentary overloads.

Recognizing the advantages of electrical drive in the rolling mill, the various constituent companies of the United States Steel Corporation and the large independent mills of the country are making extensive use of this system. In order to observe its practical application, let us take, for example, a single motor, one of 180 H. P., 230 volts, 88 revolutions per minute, furnished by the Allis-Chalmers Company, of Milwaukee, for the Youngstown, Ohio, plant of the Carnegie Steel Company, and installed complete, with yoke, shaft, pedestals and armature, for raising and lowering the tables of a blooming mill.

The gear reduction for this blooming mill will be about 6.5 to 1, based on a speed of 100 revolutions per minute of the motor shaft, and the motor will be required for continuous operation at full load for twenty-four hours without rising in temperature, in any part, more than 45 degrees C. above the surrounding atmosphere, and without sparking at the brushes.

The machine will be used to raise and lower both front and rear tables of a three-high blooming mill table, making fifteen operations (seven and one-half complete cycles) per minute. No binding wires will be used on the body of the armature. The shaft will be made replaceable without disturbing commutator or winding, and extended on the commutator end for a magnetic brake.

Ten years ago it is doubtful if the most sanguine friends of electrical drive in rolling mills would have predicted that in so short a time the adoption of electric power for driving heavy rolling mills would become common.

The line of improvement in electrical machinery, which has probably done most to encourage its adoption in mill operation, has been that of developing a high torque at starting. Electricity has thus far found no limit in iron and steel works operations. It has conquered in one direction after another. Its most recent success in driving the heaviest machinery leaves no field unassailed. It is the universal power which helps to raise the iron ore from the ground, separates it, when necessary, by another form of its power from the gangue, drives machinery in various processes through the conversion into finished product, furnishes light at all stages, and even by magnetic attraction lifts huge pieces of steel when they must be carried from one point to another.

Electric Train Lighting Systems

By W. H. RADCLIFFE

FIG. 1.—BATTERY TRAYS IN PLACE ON AN AUSTRIAN POSTAL CAR

ELECTRICITY, although first used commercially for train lighting in the early eighties, has not until recently been employed to any appreciable extent for this purpose. Oil and gas have been used almost entirely for light in transportation.

The dangers inherent to the use of oil or gas in the case of fire, their consumption of the oxygen in the air, the disagreeable odours emitted by them, and their lack of flexibility in comparison with electricity, have for several years past aroused the interest of engineers and transportation companies in the electric train lighting problem. The result has been that the apparatus for this purpose now on the market is simpler in operation, of improved design, and more substantially built than in the past, and bids fair within the next few years to offset the long period during which the advantages of the electric system were not sufficiently appreciated to warrant its development.

These advantages, some of which are due to improvements lately made in the electric system, may be summarized as follows:—

The light is brilliant and can be better distributed in small units than in oil and gas systems. There is less heating, no vitiation of the air, and no odour, making the cars more comfortable and more healthful at all times. No danger exists from explosions and asphyxiations, and the fire risk is less than with oil or gas. The system of control is more perfect, the lights are unaffected by draughts, and there is greater cleanliness. Fan motors and warming devices may be operated by the current, and also illuminated signs and vestibule step lamps which light automatically when the train stops, and extinguish themselves after the train starts.

FIG. 2.—INTERIOR OF CAR LIGHTING STORAGE BATTERY CHARGING STATION AT PRAGUE

In providing the necessities and

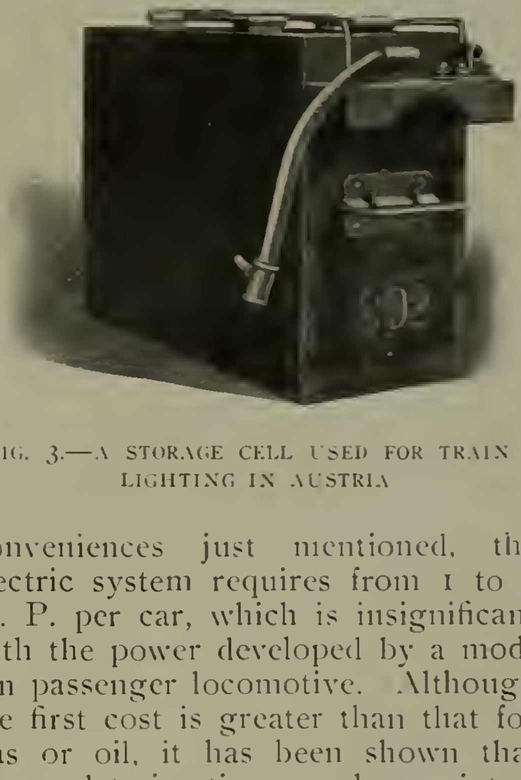


FIG. 3.—A STORAGE CELL USED FOR TRAIN LIGHTING IN AUSTRIA

conveniences just mentioned, the electric system requires from 1 to 2 H. P. per car, which is insignificant with the power developed by a modern passenger locomotive. Although the first cost is greater than that for gas or oil, it has been shown that when deterioration, up-keep, interest and all essential factors are considered, a candle-power-hour can be produced for about 68 per cent. of the cost with gas. For a full battery equipment, about $600 per car is a fair allowance; this with $300 or $400 added for wiring is not large in comparison with $8000 to $10,000, the cost of a coach, or in comparison with $16,000 to $20,000 expended for a sleeper.

Three systems of electric train lighting are now in use:—The storage battery system, in which the cars are equipped only with batteries as the source of power, the cells when run down being removed from the cars and replaced by others freshly

FIG. 4.—AN AUSTRIAN MAIL CAR LIGHTED BY ELECTRICITY

charged; the single-unit engine-generator system in which the steam from the locomotive is used in a turbine carried on the train to drive a generator, and this in turn by the aid of batteries, in each car, to furnish the current; and the multiple-unit, axle-lighting system, in which a generator is driven by the car axle and works in connection with a battery, as in the previous case.

The storage battery is a factor in all three systems owing to the necessity of current being provided when the train is standing still and when the cars are disconnected from each other. In the second system, however, when the trains are run solid from one end of the line to the other, the battery may be dispensed with. It is largely owing to the facts that the battery plays so important a part in electric lighting systems, and that heretofore its construction has not been such as to withstand the vibrations and jars railway traveling imposes upon it that gas and oil have been so generally used.

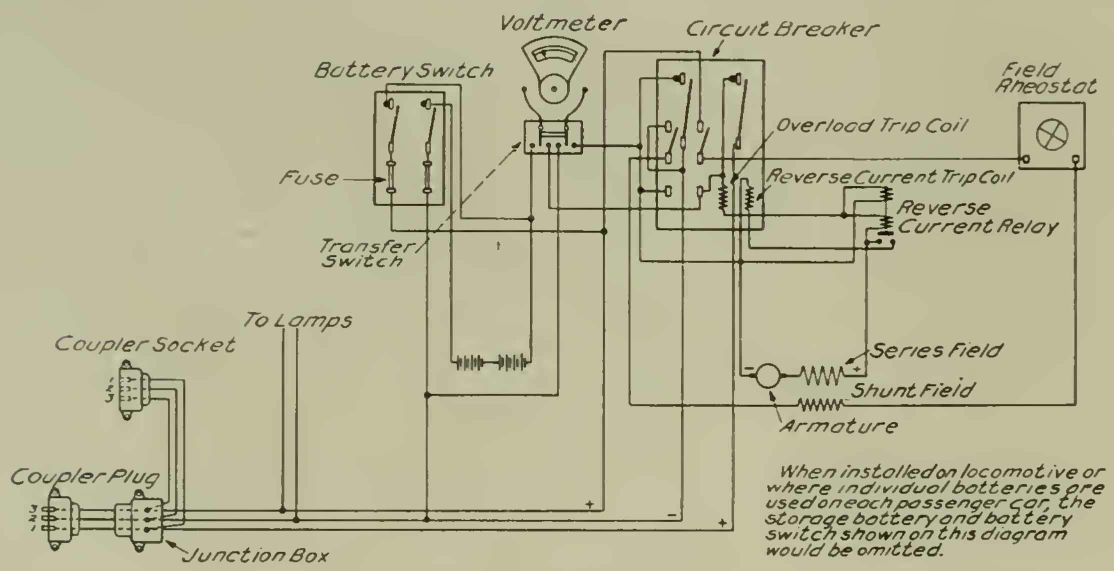


FIG. 5.—DIAGRAM OF CONNECTIONS BETWEEN THE BATTERIES AND TURBO-GENERATOR

The storage-battery system is undoubtedly the simplest of the three equipments. It is not used to any extent in America, but in Austria, about sixty postal cars are lighted in this way.

The proper lighting of postal cars is a matter of great importance in the operation of a railroad. With oil or gas the extreme heat above the heads of the postal clerks and the vitiating effect on the air of the car naturally have a detrimental effect on the clerks in the sorting and distribution of mail mater, where that work is carried on during the night. Mail cars are generally placed at the front end of the trains, and often the damage in a wreck to the equipment of a train is slight compared to the enormous loss of valuable express and mail matter consumed in the fires which have followed, caused by ignition of the oil or gas used in lighting the cars. With electric light these objectionable features are eliminated.

Fig. 4 shows an interior view of one of the Austrian postal cars lighted by electricity. Each car is equipped with from eleven to nineteen lamps of 10 candle-power, operating at from 2 to 2.1 watts per candle. The pressure used is 20 volts, furnished by battery cells, having a capacity of 150 ampere-hours when discharged at a rate of five amperes.

The battery is arranged in five trays of two cells each, and is mounted under the car as shown in Fig. 1. In ordinary service one charge lights a car for 36 hours. The cells are charged at a rate of from 50 to 60 amperes, 2 or 3 hours being required. Fig. 2 shows an interior of the charging station in Prague, Austro-Hungary, and indicates the arrangement of the switchboard and of the battery cells for charging.

The simplicity of the storage-battery system is its chief advantage in comparison with the other two electric train-lighting systems. The disadvantages are that the battery is of considerable weight and the charging of it is inconvenient and expensive.

The single-unit engine-generator system has been quite thoroughly developed by the General Electric Company, of Schenectady, N. Y. In this system, a non-condensing single-stage steam turbine is direct-connected to a 20-KW., bipolar, compound-wound generator.

The generating set is very compact, being only 64 inches long, 23 inches wide, and 24½ inches high. It weighs 1850 pounds, and operates at a speed of 4500 revolutions per minute. It is placed either in the baggage car as shown in Fig. 7, or on the locomotive. Full boiler pressure is available and no high-pressure steam couplings need be used in the latter case, although if the generating set be placed in the baggage car it is more accessible and can be given closer attention.

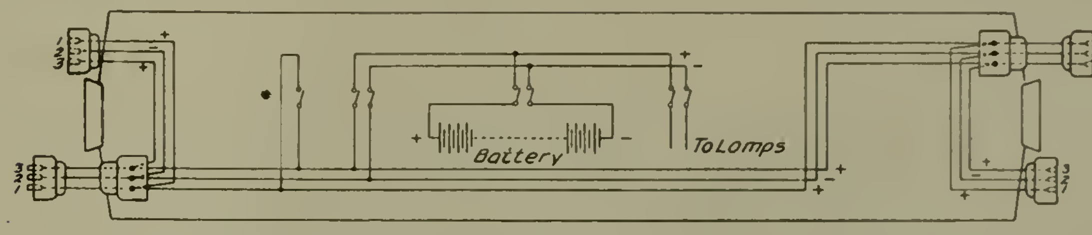
The battery consists of 56 cells giving approximately 110 volts, and is of such size that the 1-hour discharge rate is equal to the full load required by the entire train; it is used either in a single group or distributed through the cars, depending upon whether or not the train runs solid between termini.

In the former case, the cells are placed in the baggage car and are wired to the generator as in Fig. 5. If the locomotive is not charged from one end of the train to the other, the battery may, if desired, be entirely dispensed with. In the latter case, the car carrying the generating set is wired as in Fig. 5, and the remaining cars of the train are wired as in Fig. 6.

The single-unit engine-generator system has the advantage of utilizing apparatus which has become standardized and which in consequence is of comparatively high efficiency. The generator is run at a uniform speed, and thus gives a practically constant voltage. The system is advantageous also in that the apparatus used is of light weight, is comparatively cheap to install, and has a minimum depreciation and maintenance cost. It ranks next to the storage-battery system in simplicity, the various units being under one control. There is, furthermore, good potential regulation. As the generating set can be placed inside the car, it is protected from injury and kept in good condition.

To counterbalance these advantages are the valuable space occupied by the generating set, when placed in the car, the attendance required en route, the flexible connections between the cars, and the storage battery needed for the lights while the locomotive is disconnected from the train.

The majority of train-lighting systems belong to the multiple-unit axle-lighting type. The Bliss system brought out by the Bliss Electric Car Lighting Company, of Milwaukee, Wis., is of this kind. It consists essentially of the following apparatus:—A generator mounted upon the truck frame and driven by the axle; a regulator mounted on the bottom of the car body for controlling the output of the generator and maintaining the lamp voltage constant irrespective of the speed of the car and the number of lamps in use;



* This switch is closed on rear car in train only

FIG. 6.—DIAGRAM OF CONNECTIONS IN A PASSENGER CAR WITH THE GENERAL ELECTRIC SYSTEM

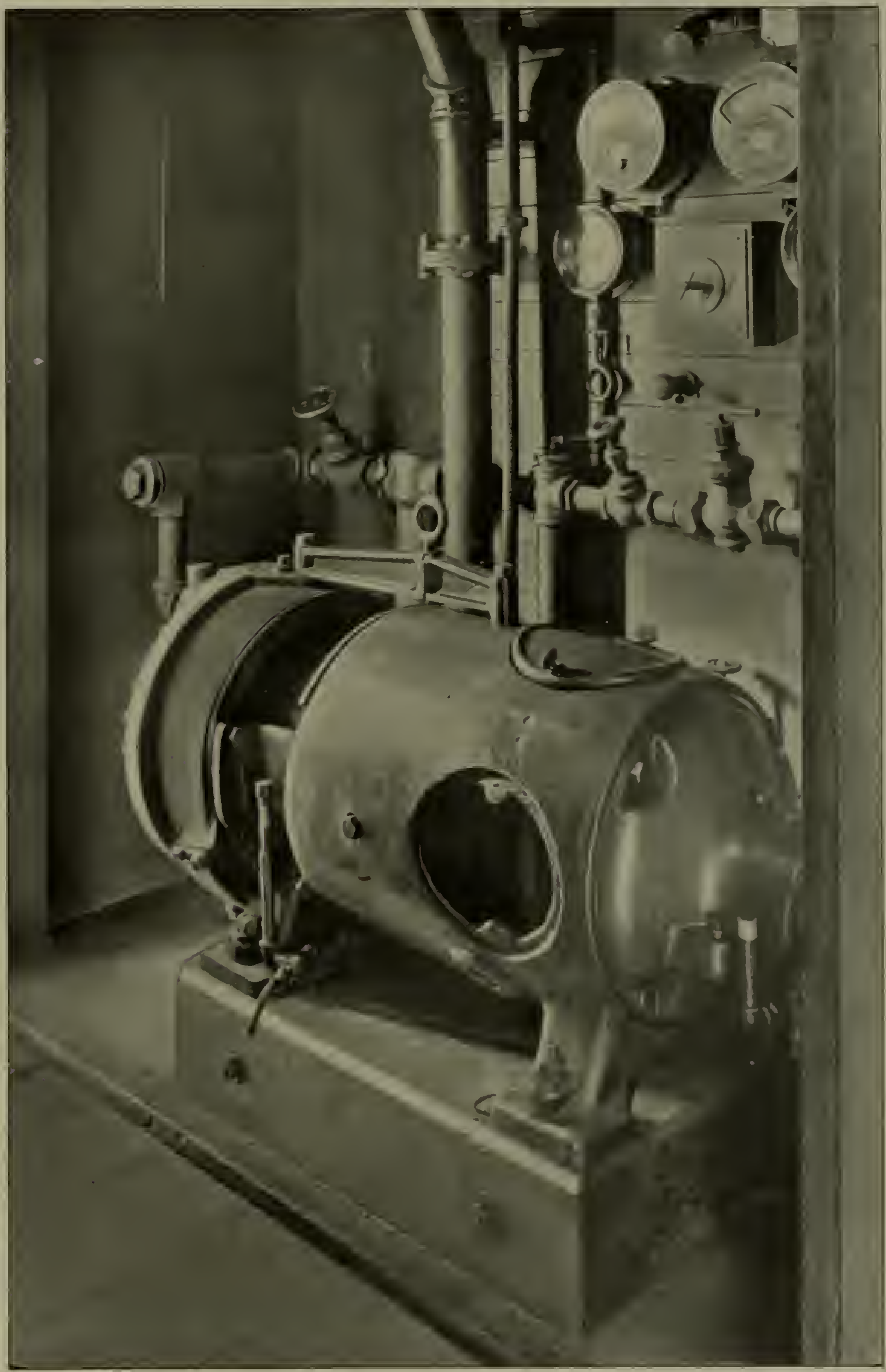


FIG. 7.—BAGGAGE CAR EQUIPPED WITH A CURTIS STEAM-TURBINE-DRIVEN GENERATOR FOR ELECTRIC TRAIN LIGHTING

and an automatic switch mounted inside the car for controlling the connection of the generator with the rest of the system. In addition, there

FIG. 8.—VIEW OF GENERATOR AND METHOD OF SUSPENSION IN THE SYSTEM OF THE BLISS ELECTRIC CAR LIGHTING COMPANY, OF MILWAUKEE, WIS.

FIG. 9.—THE BUCKER USED IN THE BLISS SYSTEM. THE COUPLER HEAD AND BLOCK FOR CONNECTING THE CAR WIRES ARE ALSO SHOWN

must be provided on each car a storage battery and the wiring, fixtures, lamps, circuits, switches, etc.

The current from the generator, after passing through the switch

FIG. 10.—GENERATOR SWITCH OF THE BLISS SYSTEM

shown in the left-hand upper corner of Fig. 11, divides, part of it passing through the lamps and part through the storage battery, so as to charge the cells, and also through the field-winding of the regulator or "bucker" on its way back to the generator. The current used to excite the field magnets of the generator passes by means of brushes through the commutator on one side of the bucker armature, and the current that has passed through the lamps passes through the other commutator of the bucker.

The two commutators are each connected to an independent winding, wound on the same core, the winding in the lamp circuit being composed of a comparatively small number of turns of heavy wire, and the winding in the generator field circuit of a large number of turns of fine wire. The armature shaft of the bucker carries also another armature provided with shunt field magnets, and this shunt motor is driven by the current from the generator.

Counter voltages are generated automatically in the two windings of the bucker, the one providing the necessary regulation for the generator field as the speed increases, and the other increasing as the charging voltage of the battery increases, thus keeping the lamp voltage constant.

As the car accelerates, the generator develops an increasing voltage, sending current through the different circuits connected with it and starting the motor armature of the bucker. When the car reaches the operating speed, the generator will develop normal lamp voltage and the bucker will be running at full speed. The automatic switch will then close, connecting the generator to the rest of the system and supplying current to the lamps. A further increase of speed would tend to increase the voltage, but the opposing influence of the bucker in the field circuit weakens the field and keeps the output of the generator within the predetermined limits.

At the same time the opposing effect of the bucker in the lamp circuit prevents the increase in lamp voltage due to the higher speed of the generator as the car increases in speed. A change in the number of lamps in circuit will also have no effect on the lamp voltage, since the bucking effect is the same, irrespective of the current which may flow against it.

In Europe a multi-unit axle-lighting system controlled by J. Stone & Co., Ltd., of Deptford, London, has been largely used. As shown by the diagrams in Fig. 13, the generator for this system is suspended, so that its pulley is approximately at the same level as the pulley on the car axle, from which it is driven by means of a belt. Part of the current generated is used by the lamps and the remainder is stored in accumulators, one-half of which acts as regulator to the other half and automatically comes into action when the train slackens speed or stops at stations, without any attention what-

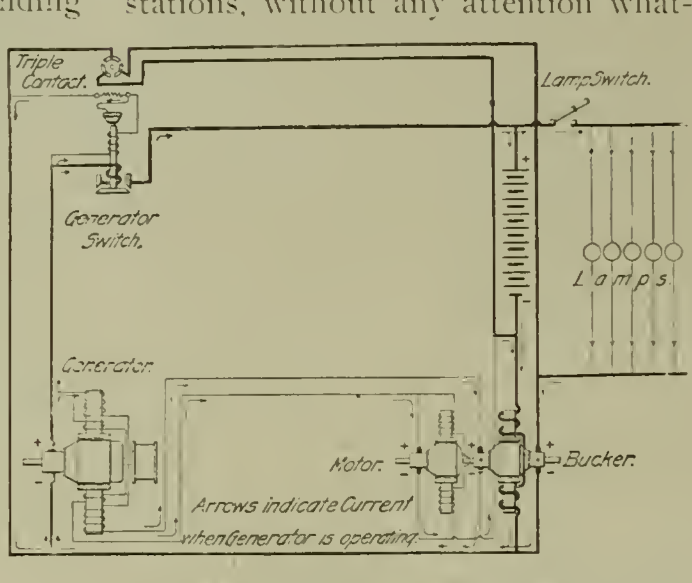


FIG. 11.—DIAGRAM SHOWING CONNECTIONS OF THE BLISS SYSTEM

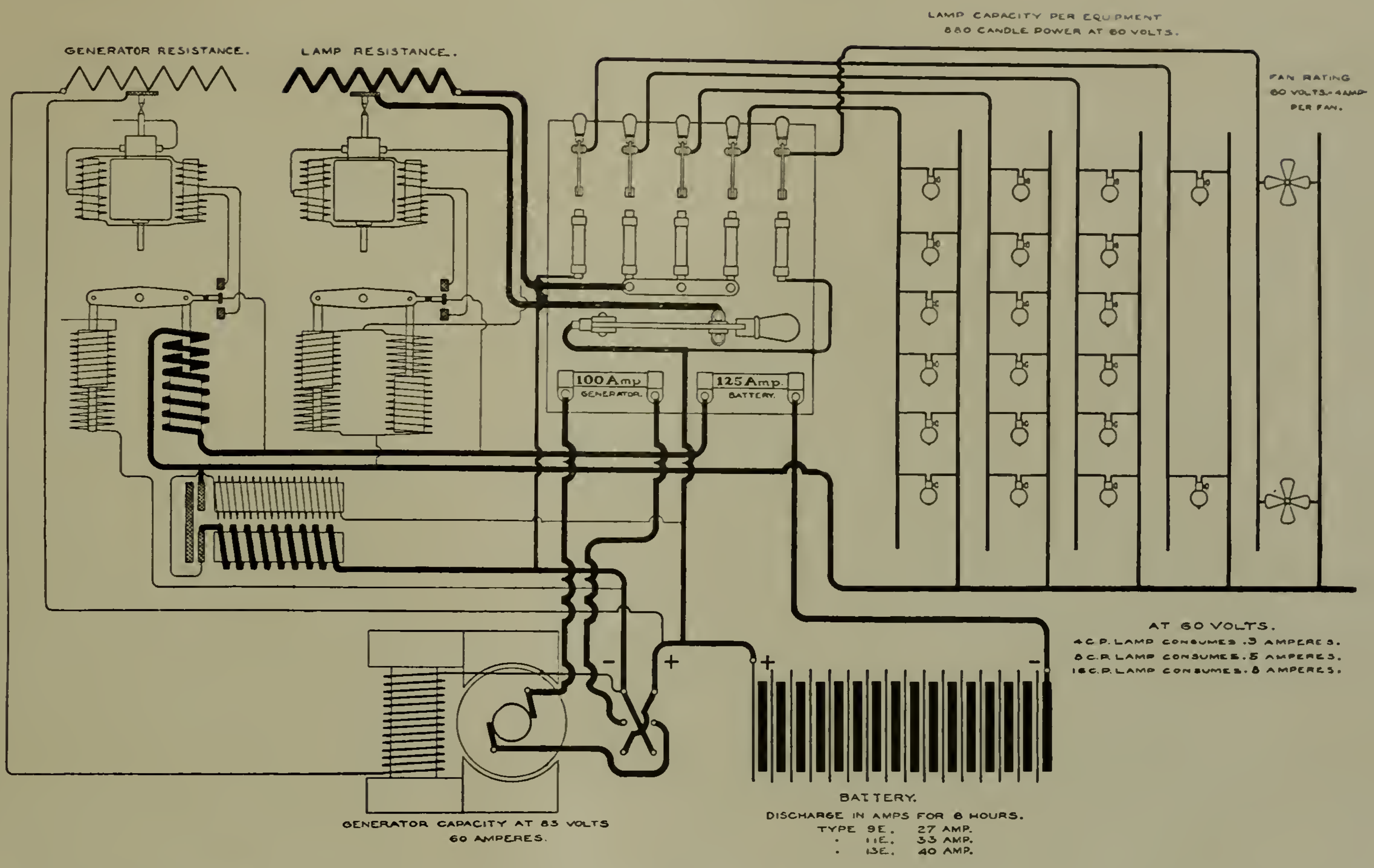


FIG. 12.—WIRING DIAGRAM OF THE MC ELROY AUTOMATIC CAR LIGHTING SYSTEM OF THE CONSOLIDATED CAR HEATING COMPANY, NEW YORK

ever. The generator runs at a uniform speed, and maintains a uniform pressure after a certain pre-determined speed is reached, regardless of variations in the speed of the train. The result is secured by suspending the generator by an adjustable link, so that the former can swing towards or away from the driving pulley on the axle.

The link allows the driving belt to draw the generator out of the diagonal position in which it would naturally hang, and so put a definite tension on the belt just sufficient to transmit power equivalent to the amount of electricity required. Thus when the pull on the belt, owing to increase in speed of the train exceeds the weight on the belt due to the one-sided suspension of the generator, the generator will automatically be drawn towards the driving pulley on the axle and allow the belt to slip while the armature continues to rotate at its normal speed.

A mechanical governor automatically makes connection between the generator and the storage battery while the train is in motion, but on slowing down or stopping, the lamps are supplied by the storage battery alone.

The McElroy car-lighting system of the Consolidated Car Heating Company, of New York, is also worthy of note in connection with the multiple-unit axle-lighting types. The equipment comprises a generator driven by a gear attached to the car axle and a raw-hide pinion on the end of the armature shaft,—both of which are inclosed to protect them against flying particles from the road-bed and require no lubrication,—an automatic regulator for governing the generator output, lamp voltage, and battery charging, and the storage battery.

The generator, shown in Fig. 14, is of the shunt-wound, four-pole type. It has an output of 50 amperes at 83 volts, and can supply current sufficient for lighting 110 8-candle-power lamps at 60 volts, and at the same time charge the

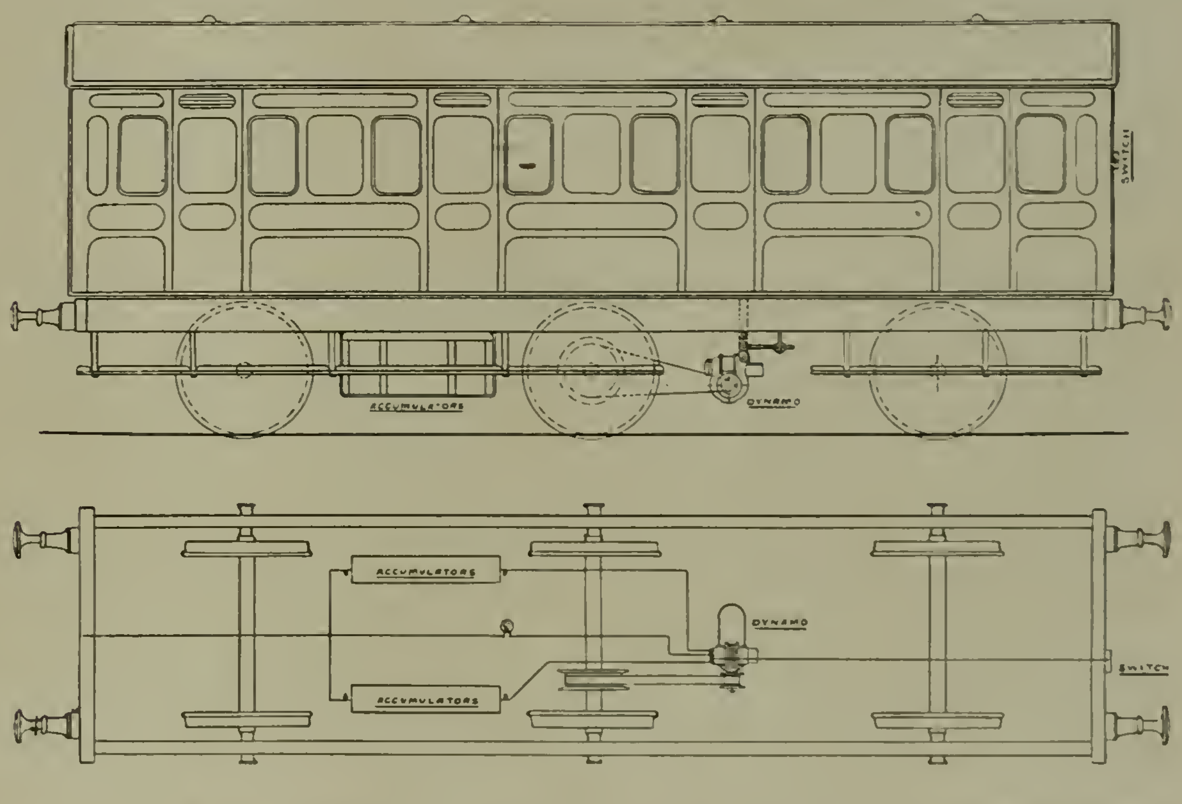


FIG. 13.—A BRITISH PASSENGER COACH EQUIPPED WITH THE ELECTRIC LIGHTING SYSTEM OF J. STONE & COMPANY, LTD., DEPTFORD, LONDON

battery. Ball bearings are used on the armature shaft to reduce the frictional load to a minimum. These bearings require oiling only at periods of from four to six months.

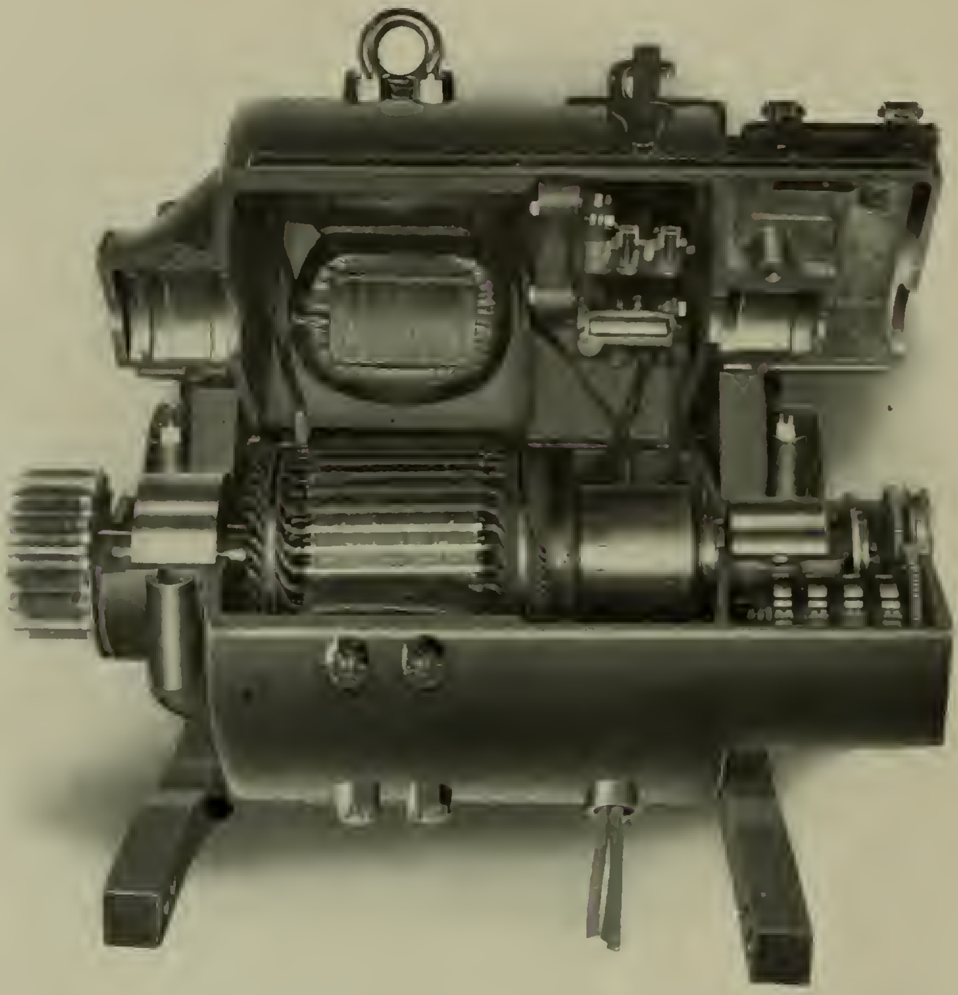


FIG. 14.—GENERATOR USED IN THE MC ELROY TRAIN LIGHTING SYSTEM OF THE CONSOLIDATED CAR HEATING COMPANY, OF NEW YORK

The reversing switch for maintaining the same relative polarity in the external circuit regardless of the direction in which the car may be moving, is shown in Fig. 14, located in a compartment at the right of the generator. The construction of the switch is similar to that of the reversing drum switch on a street car controller.

Fig. 16 shows the regulator. The method of regulation will be best understood by referring to the diagram of wiring in Fig. 12. The voltage of the dynamo is controlled by a field rheostat operated by a small series, double-field, reverse-wound motor in the regulator case. The rotation of the motor is governed by the combined action of two solenoids which act against the tension of a spring. One solenoid is a shunt-wound coil connected across the generator mains, and the other is a series-wound coil in the battery circuit.

When the generator is supplying current these two coils act in conjunction. So long as the pull of the solenoids just balances the tension of the spring, the arm of the automatic switch is in its mid-position; here the motor circuit is broken, and the rheostat arm remains stationary until a change in the voltage of the generator destroys the equilibrium between the pull of the spring and that of the solenoid, when the motor will again receive current and the rheostats be so adjusted as to

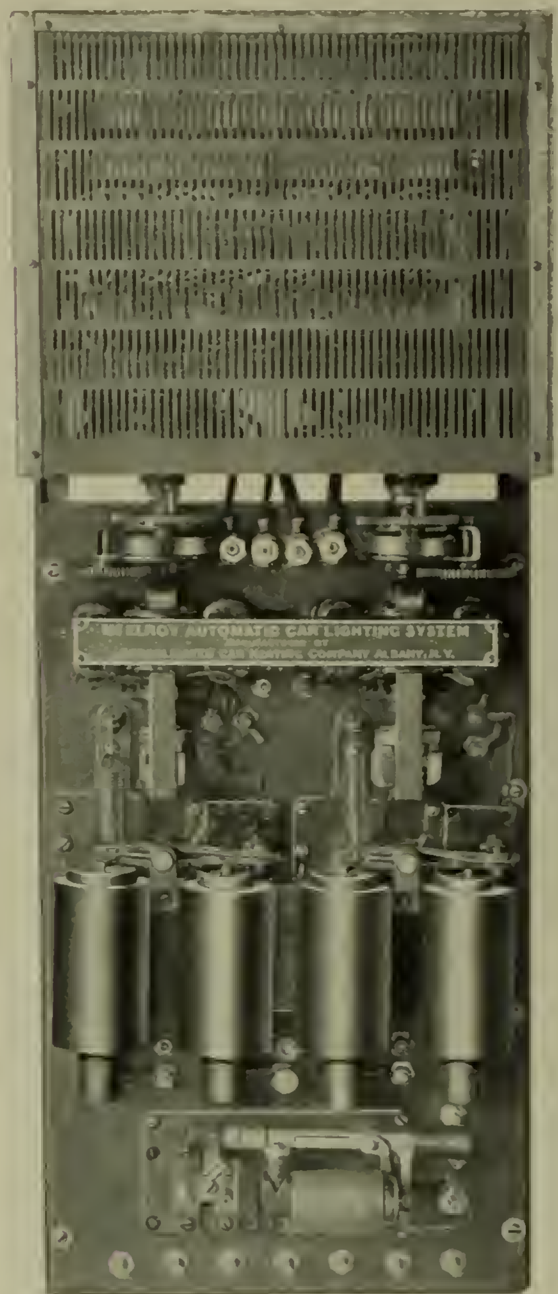


FIG. 16.—REGULATOR OF THE MC ELROY SYSTEM

bring the voltage of the generator to the correct value.

The switch connecting the generator and battery is automatically opened when the voltage of the generator equals the voltage of the battery. The operation is positive and takes place at zero difference of potential, so that no arcing occurs when the circuit is opened. In reversing the operation, when connection is made to the battery, there is also zero difference of potential at the terminals which are connected, and the generator picks up the lamp load without fluctuation of the lights. The lamp voltage is controlled

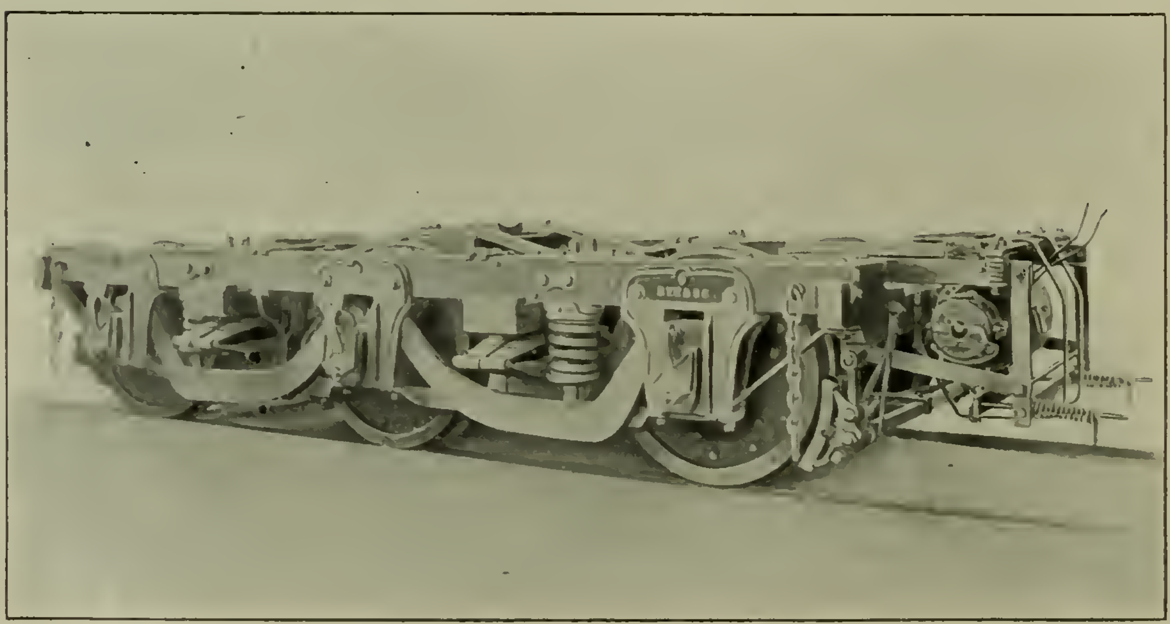


FIG. 15.—CAR TRUCK, SHOWING METHOD OF GENERATOR SUSPENSION IN THE MOSKOWITZ SYSTEM OF THE UNITED STATES LIGHT & HEATING COMPANY, OF NEW YORK

through an independent rheostat operated by another motor, which is controlled by a solenoid connected across the lamp mains and is independent of whether the current is supplied from the generator when the car is in motion or from the battery when it is standing still. The lamps can be turned on or off at will, either singly or in groups, without affecting the remaining lights, as the regulator immediately adjusts the resistance to maintain the fixed voltage across the lamp terminals. Regulation of the lamp voltage is constantly maintained within 1 per cent. of the mean value.

A 32-cell battery is used with this equipment, the size varying accord-

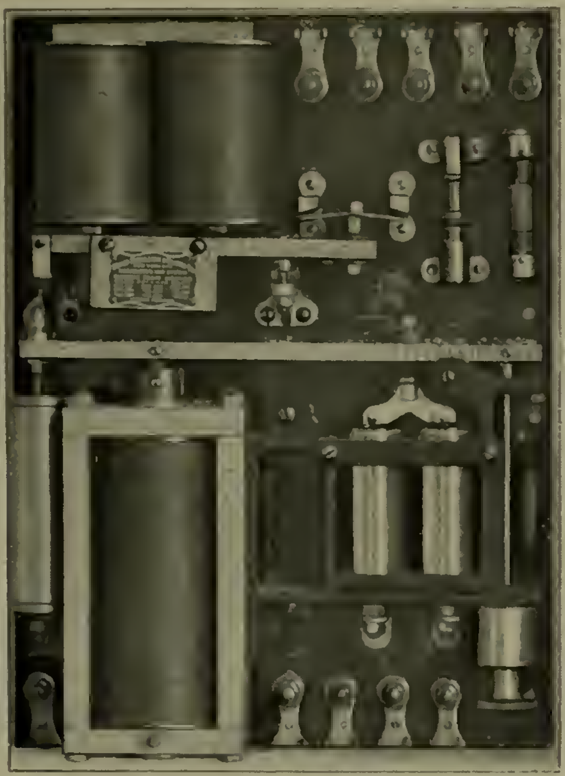


FIG. 17.—REGULATOR OF THE MOSKOWITZ SYSTEM

ing to the number of lamps in the car. Owing to the fact that the capacity of the dynamo is such that the battery can be charged at the same time that the lamps are being run direct from the machine, it is not necessary to provide large storage capacity. A battery capable of carrying the lamp load for 5 or 6 hours is deemed entirely sufficient for all purposes.

The system of the United States Light & Heating Company, of New York, controlling Moskowitz patents, is another example of the multiple-unit axle-lighting type. The generator is here suspended outside of the end sill of the car truck, as shown in Fig. 15, where a single truck is illustrated. The suspension here is what is known as a spring cushion foundation, and allows the generator to swing as a pendulum. This, it is claimed, secures the proper belt tension at all times.

The electrically lighted car shown in Fig. 20 is used by the New York Central & Hudson River Railroad on the Empire State Express. The storage battery is located in the box shown at the centre under the car body. In case the train becomes side-tracked or stopped, as in a snowstorm, the batteries are guaranteed to furnish current for lighting all the lamps installed during 12 hours. By decreasing the number of lights to one-quarter the full number, they would give ample light for four nights or longer than provision is made by any other kind of illumination for the blocked train.

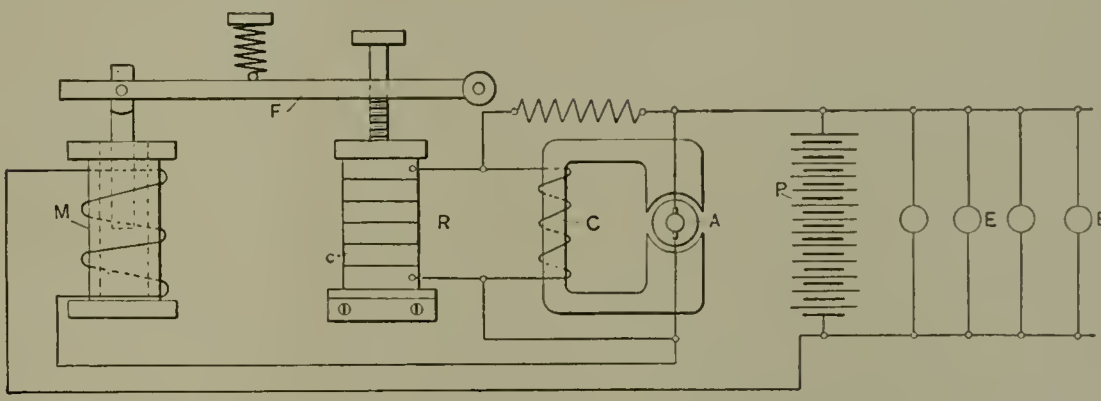


FIG. 18.—DIAGRAM OF WIRING CONNECTIONS OF THE MOSKOWITZ SYSTEM

The method of regulation used in the Moskowitz system possesses the advantage of being very simple. There are no gears, rheostats, nor constantly moving parts. The principle is shown diagrammatically in Fig. 18. The generator *A* is spring-supported from the car truck, and is driven from the axle by a belt. It is shunt wound, and is regulated by means of a device similar to that employed in the Brush constant-current arc machines.

In multiple with the shunt field *C* is connected a pile *R* of carbon blocks *c*, which are arranged so as to be pressed together by a lever *F* when the latter is pulled down by the solenoid *M*. This solenoid is joined in series with the main circuit of the generator, and with the storage battery *P* and lamps *E*. The battery and lamps are joined in parallel, as shown. If the generator, owing to excessive speed, tends to produce too large a current, the lever *F* is pulled down, thereby compressing the carbon blocks *c*; their resistance being thus reduced, the current is shunted away from the field *C*, and this brings the voltage (and hence the current) of the machine back to normal.

In conclusion, it may be said that multiple-unit axle-lighting systems are advantageous in that there is no attendance required en route, that power is obtained without connec-

FIG. 19.—A POSTAL CAR LIGHTED ON THE MOSKOWITZ SYSTEM OF THE UNITED STATES LIGHT & HEATING COMPANY

FIG. 20.—AN "EMPIRE STATE EXPRESS" CAR ON THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD LIGHTED BY THE MOSKOWITZ SYSTEM

tions between the cars, and that the illumination of each car is independent of the conditions of any other car of the train. The disadvantages are:—The apparatus is in part exposed and subject to mechanical injury; storage batteries must necessarily be used; erratic current generation develops commutator troubles; the units must be small and therefore comparatively inefficient; compensation for reversal of rotation complicates matters; the first cost is high, and the depreciation and maintenance are not low.

Several of these disadvantages are overcome wholly or in part in different systems, and while there is a still opportunity for improvement along the lines mentioned, the practicability of multiple-unit axle-lighting system is proved by its adoption in one form or another, by over thirty prominent railway companies in the United States, and by more than 130 railway companies abroad.

The Production of Mica in the United States in 1905

ACCORDING to the annual report of the United States Geological Survey, the production in the United States of mica in 1905 made an important advance over that for 1904. Production was limited to six States:—North Carolina, Colorado, New Hampshire, Georgia, South Dakota and New Mexico, the order named indicating their relative rank. The total output of sheet mica for these States, as reported to the Survey, was 851,000 pounds, with a total value of $185,900. Of this quantity North Carolina is credited with 669,000 pounds, valued at $85,000. The increase in production over the previous year was largely in other States, while the larger increase in value may be accounted for in part by high prices reported by producers in those States.

A decrease in the average price for the North Carolina product is due to the increasing proportion of small mica produced for electrical uses. The total production of scrap mica in the United States in 1905 was 856 net tons, valued at $15,255, an increase in value over the production for 1904. North Carolina's output of scrap mica for 1905 was 175 tons, valued at $2375. The separation of the production figures for scrap mica and for the smaller sizes of sheet mica becomes more difficult as the use of these small sizes increases.

The production of sheet mica in 1904 was 668,358 pounds, valued at $109,462, and of scrap mica 1096 net tons, valued at $10,854. Thus the value of the aggregated product of mica in 1905 was $201,155, as compared with $120,316 in 1904. The value of imported mica now used in the United States is twice that of the domestic article. In 1905, 1,506,382 pounds of unmanufactured mica, valued at $352,475, and 88,188 pounds of cut or trimmed mica, valued at $51,281, were imported, making a total of 1,594,570 pounds, valued at $403,756.

The three principal uses of mica are for electrical insulation, glazing and decoration. The first-named application probably leads in present importance, but the other two uses date back to ancient times, mica antedating glass and also being early used to secure decorative effects.

The increasing use of mica in electrical manufacture has largely modified the demand made upon the mining industry. Small sizes of sheet mica can now be utilized in the manufacture of insulators in lamp sockets, lightning arresters, switch boxes and fuse blocks. More important even is the extensive use that is made of composite mica, micanite, moulded mica and other varieties of built up mica sheets. In the manufacture of material of this class thin laminae of irregular form and different sizes are arranged and cemented together to form thick sheets of any desired size.

German Electrical Working Agreement

UNDER date of August 17 the Berlin correspondent of the London "Times" Engineering Supplement writes:—

"The arangement for the redistribution of capital among the three great electrical undertakings,—the Allgemeine Elektricitäts Gesellschaft, Siemens-Schuckert and the Lahmeyer group,—has recently undergone certain modifications, in that mutual agreements have been concluded for the adoption of a protective cartel, in accordance with which the three rival concerns will merge their conflicting interests. The object of this intimate form of fusion will be to safeguard each of the allied firms in submitting tenders for work for the execution of which, in consequence of previous business relations, any one of them would possess paramount claims. This will be effected by engagements on the part of the two other firms in the cartel to make their tenders in such cases higher than that of their rival. Firms not in the combine are either individually too feeble to oppose effectually the vast united interests ranged against them, or, on the other hand, their undertakings are too diverse in character to enable them successfully to attempt any joint resistance to the trust."

The most prolific natural gas well, says the "Mining and Scientific Press," usually produces little or no oil. Where a large volume of gas exists in rock strata it generally issues when tapped by the boring drill under tremendous pressure, in some instances blowing the string of tools out of the hole and wrecking the derrick. One of the most noted gas wells in the world is the McConkey, which flows 30,000,000 cubic feet per day with a static pressure of 960 pounds per square inch. Gas is distributed from this well through an extensive system of pipes, pressure being equalized over long distances by means of compressors.

The Control of Motors on Electric Light and Power Circuits

By H. D. JAMES

From a Paper Read at the Recent Convention of the National Electric Light Association

IT is the intention of this paper to treat of the control problems only, and the writer assumes that the general characteristics of the different motors are generally known.

To assist in understanding the general methods of control, the following table has been prepared, dividing the control of motors into general classes and again into subdivisions. In a number of cases these divisions have had to be assumed arbitrarily and are intended only for convenience in following this paper:—

GENERAL CLASSIFICATION OF CONTROL SYSTEMS

Rheostatic	Direct current	Resistance in series with the armature. Resistance in both series and parallel with the armature.
	Alternating current	Resistance in series with the primary. Resistance in series with the secondary.
Voltage	Direct current	Changing voltage at motor terminals. Series—Parallel. Using several lines of different voltages.
	Alternating current	Changing impressed voltage by transformers. Series—Parallel.
Changing Motor Characteristics	Direct current	Changing field strength. Changing number of armature conductors in series. Changing the number of poles.
	Alternating current	Changing the number of poles. Changing the frequency (cascade connection).
Mechanical Devices	The use of gearing, clutches, etc. Using two or more motors geared for different speeds. Varying the amount of iron in the field poles. Varying the air gap between the armature and field.	
Braking	Mechanical	Brake released by a magnet.
	Electrical	Brake obtained by operating the motor as a generator.

RHEOSTATIC CONTROL—DIRECT CURRENT

The oldest and perhaps best known method of control consists in reducing the voltage at the motor terminals by means of resistance in series with the armature. This method of control is embodied in all direct-current starting devices, from the small face plate to the heaviest unit-switch device.

Face-Plate and Unit-Switch Starters—Face-plate starting devices are generally built in but one form, consisting of an arm passing over a series of contacts which gradually short-circuits sections of the resistance until the arm reaches the last position in which all of the resistance is short-circuited. The arm is held in this position by means of a magnet connected across the line, sometimes in series with the shunt field of the motor. This magnet releases the arm should the voltage on the system fail and the spring returns the arm to the off position.

This is a very convenient arrangement, but one which is not embodied in commercial controllers, other than the above type, until we reach the large controllers consisting of electrically operated switches, or the large hand starters which have a no-voltage coil for tripping the circuit-breakers when the line voltage fails. At various times controllers have been built in which the drum is returned to the off position when tripped by the release of a shunt coil, but they have not come into general use. There has also been placed on the market a type of controller which is a combination of the drum switch having an electrically operated switch used in connection with same. In general, however, the drum and face-plate controllers used for intermittent service do not embody such a device.

Regulating Controllers—Rheostatic controllers for regulating purposes are generally used in connection with series or compound-wound motors. The torque of a series motor varies approximately as the square of the current, therefore a wide range of speed regulation can be obtained by varying the current through a comparatively small range. In most cases this variation in current does not exceed 40 to 50 per cent. With a compound-wound motor more range of current value is required.

The torque of the shunt motor varies directly with the current, so that this motor is not well suited for rheostatic control. This form of control is used extensively for cranes, hoists, bending rolls and intermittent service of this character. The two forms of mechanical controllers are used. The drum type of controller has a rotary motion of the handle and separately mounted resistance. This controller can be readily enclosed and is compact in construction, but the rotary motion of the handle is sometimes objectionable. The disc type of controller consists of either a face plate or grindstone, upon which a series of contacts are fastened. The brush holders are moved over these contacts by the reciprocating motion of the controller handle. These controllers, being flat in construction, can readily have the resistance mounted in the same frame as the switching mechanism.

They can also be operated at a distance by means of a bell crank and levers. For this reason they are used extensively for cranes and in other places where it is not desirable to have the controller located in front of the operator, the reciprocating motion of the handle being similar to the motion of an engine lever. This motion of the controller handle is very convenient when a motor is substituted for a steam engine. If the resistance is mounted with the controller it is not so convenient to protect it from the weather, but in most cases the controllers can be placed under cover.

Automatic Controllers—The dash-pot type of controller is perhaps the oldest form which is automatic in its operation. The arm which cuts out the resistance passes over a series of contacts under the tension of a spring or weight, the motion being retarded by a dash-pot. This control has been successful for small capacities.

For larger capacities an automatic control has been developed, consisting of a series of electrically operated switches. These switches are actuated by means of a master switch and the rate of cutting out resistance can be made automatic by using some function of the counter electromotive force of the motor, or the value of the current in the armature circuit. Such controllers are very durable, as a powerful magnetic blow-out can be used and the opening and closing of the switches is performed quickly by means of a magnet. Arcing tips can be provided which are readily renewable.

The switches can be made interchangeable, so that repair parts for only one switch need be carried in stock. The switches can be mounted in any convenient manner best suited to the particular application. This form of controller can be readily designed to meet any reasonable starting condition. Recent developments have reduced the cost and complication of this type of controller and materially increased its durability.

With a controller of this type the current taken at the time of acceleration can be limited to any desired amount and the full value of this current will always be available, thus giving the maximum acceleration without injury to the motor. If the motor is suddenly reversed, the automatic feature will prevent the resistance from being cut out of the armature circuit until the current has decreased to a predetermined value. In this way the "plugging" of a motor is automatically limited.

The unit-switch type of control is well adapted for automatically starting pumps, air compressors, elevators, etc. It is used for printing presses, mill tables, cranes, ore bridges, car dumpers and many special purposes, and is particularly adapted to cases where the operating conditions are very severe.

This form of control has recently been subjected to a very severe test, as follows:—

The controller was connected to a motor which operates a planer, and the master switch was attached to the planer in such a way that the controller reversed the motor at the end of each stroke of the planer. The controller was so arranged that the speed of the motor could be adjusted on the cutting stroke by means of a field rheostat, but the motor always returned at the maximum speed, which in this case was four times the minimum cutting speed. The controller has been in continuous operation since December 1, and is often called upon to reverse the motor from five to six times a minute. Thus far all contacts are in first-class condition and it is probable that no renewals will be necessary for another year.

A larger type of switch was subjected to a breaking test, as follows:—

The switch was connected across a 500-volt direct-current circuit in series with two 100-H. P. railway-type motors and sufficient resistance to reduce the current to 400 amperes. The operating coil of the switch was connected to a small switch operated by clock-work. This clock-work mechanism caused the main contacts to be opened and closed quite rapidly. The switch opened the circuit under the above conditions 100,000 times without materially reducing the arcing tips. The two motors in series with the switch produced a very severe inductive kick which made the arc over twice as large as that produced with only resistance in circuit.

The above tests indicate in a general way what may be expected from this type of controller.

Series and Parallel Resistance—Resistance in series and also parallel with the motor armature has sometimes been used to reduce the speed of the motor for printing-press work. The resistance in parallel with the armature gives a certain fixed current value through the series resistance which causes a definite drop independent of the load on the armature of the motor, which in turn gives a far more stable running condition, although the efficiency is materially reduced.

ALTERNATING CURRENT

Commutator-Type Series Motors—Resistance is used in series with the single-phase commutator type motor in the same manner as with the direct-current motor. The control is practically the same, although the amount of series resistance is affected by the power factor of the motor. This form of motor is well adapted for crane and hoist purposes. It has practically the same characteristics as the direct-current series motor and the control is effected in the same manner.

Induction Motors, Slip-Ring Type—The alternating-current induction motor of the slip-ring type is controlled by inserting resistance in the secondary circuit. The speed regulation is the same as that of a direct-current shunt motor, the reduction in the speed being directly proportioned to the amount of energy absorbed in the resistance, the torque in each case being proportional to the current. The speed of the motor is different for different loads with the same amount of resistance. This form of motor has been applied extensively to cranes, mine hoists, elevators, gold dredges, pumps and similar apparatus. This method of control is also used for starting polyphase induction motors. It is particularly well adapted for starting heavy loads, the current being directly proportional to the torque required.

The maximum torque which this motor can exert can be obtained at the moment of starting by properly proportioning the secondary resistance. This torque is usually from two to three times as great as the full-load torque of the motor and requires a proportionate increase in the current.

When used for starting purposes only, the control corresponds exactly with the direct-current starter, except that no automatic release has been provided when the current fails in the circuit. Such an automatic release is not necessary, as the self-induction of the motor limits the amount of current that will flow should power again be applied to the line, and there is no commutator which could be injured as with the direct-current motor. The overload current flowing at such time would open the circuit-breakers and relieve the motor immediately. In special cases where such a device is required a no-load circuit-breaker is used.

Recently a starting device for this type of motor has been developed which is connected to the secondary of the motor only, the primary of the motor being controlled by any commercial form of switch or circuit-breaker. This enables the starting device to be placed external to the motor at any convenient place, and by winding the secondary of the motor for low voltage and grounding the center of the resistance, the operator is in no danger from shock. This starting device is entirely enclosed and dustproof, so that it can be located in cotton mills, powder factories, dyeing houses, ash-pits, and many other places where external conditions will prevent the use of an ordinary starting device.

By using a line switch to open the primary of the motor in stopping, the arcing is localized in the switch, where inspection and repairs are easily made. A line of controllers connected to the secondary of the motor only can also be obtained. The resistance for such controllers is separately mounted.

Automatic controllers of the unit-switch type are not available for this form of motors, except those operated by direct current or compressed air. A number of controllers for elevator work and similar purposes have been built by operating the magnets with direct current obtained from a small motor-generator set or other source of power. Recently controllers have been developed for larger motors of this type, employing compressed air for operating the switches. These controllers can be operated from the master switch and are applicable to hoists, conveying machinery and similar apparatus. Both the motor and the controller can be entirely enclosed where desired to protect the same both from dirt and from the weather.

Some very large unit-switch controllers operated by direct current will be used employing oil-immersed switches for high voltages. The ability to use high voltage and a correspondingly small current is a decided advantage in designing controllers for alternating-current motors.

VOLTAGE CONTROL—DIRECT CURRENT

Motor-Generator System—The system generally known as the Ward-Leonard system consists of a direct-current generator connected to a separately excited direct-current shunt motor. The voltage at the terminals of the motor is changed and reversed by changing the field current of the generator. A constant speed is obtained on every notch of the controller and as many speeds can be provided for as necessary.

This form of control is well adapted for variable-speed work, and also for reversing motors. Its application in the past has been limited, owing to the extra cost of the generator and its prime mover, whether a motor or an engine. Now, however, direct-current motors of very large sizes are being contemplated, and in a number of instances have actually been installed at various places in Europe.

To switch the armature current, which amounts in some cases to several thousand amperes, would cause prohibitive wear on the controller, but by use of this system of control only the field current of the generator is switched and the wear on the contacts has been reduced to a minimum.

Another advantage in using a separate generator for each motor is that a fly-wheel can be mounted on the shaft of the motor-generator set, and by varying the slip of the induction motor, or the field strength of the direct-current motor, this fly-wheel can be made to take the peak of the load so that a practically constant load is taken from the transmission circuit. This arrangement is known as the Ilgner system, and has been installed in a number of places in Europe. A system similar to this is practically necessary where motors of hundreds and sometimes thousands of horse-power are used.

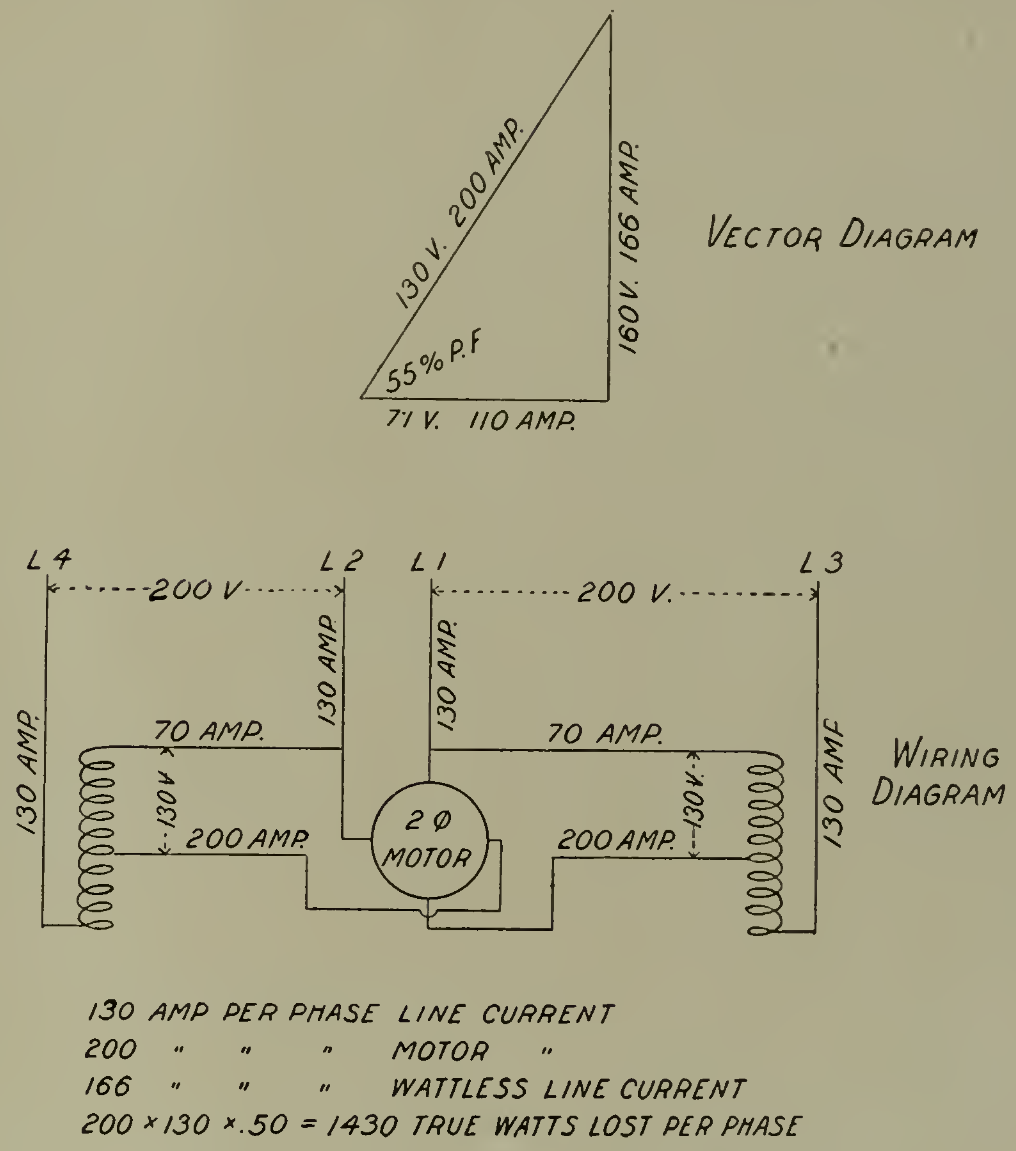


FIG. 1.—WIRING DIAGRAM OF TWO-PHASE MOTOR AND POWER CIRCUIT

ALTERNATING CURRENT

Induction Motor and Auto-Transformer—The polyphase induction motor with short-circuited secondary is usually started by changing the voltage impressed upon the motor terminals by means of a transformer; usually an auto-transformer is employed. This device is simply a single-coil transformer from which a number of taps are brought out to give various voltages. The motor is connected to the line on one side and to a tap of the transformer on the opposite side. The current in the line is less than the current in the motor in the inverse ratio of the voltages.

Fig. 1 represents the effective current in a two-phase motor and power circuit. When the motor is connected to a tap which impresses 130 volts across the motor terminals with a line voltage of 200, it will be seen that if the line current is 130 amperes and the motor current 200 amperes the transformer supplies the additional 70 amperes by which the motor current exceeds the line current. This method of starting draws the minimum current from the line. In the above example the true watts in one phase, assuming 55 per cent. power factor, are 1430, the wattless current being 166 amperes.

If a resistance were used in series with the secondary of the motor in order to reduce the voltage across the motor terminals, as shown in Fig. 2, the line current would have the same value as the motor current, and instead of the small losses from the auto-transformer we should have the still greater loss due to the energy consumed in the starting resistance. In Fig. 2 we have assumed the same starting conditions at the motor terminals as in the previous example, namely, 130 volts across the motor terminals and 200 amperes in the motor circuit, 55 power factor and 166 amperes wattless current. By referring to the vector diagram it will be seen that this triangle is the same as the triangle for the motor when started from an auto-transformer, shown in Fig. 1.

In order to reduce the 200 volts in the line to 130 volts at the motor terminals, it is necessary to insert 0.77 of an ohm resistance in each phase of the motor circuit. This increases the power factor to 83 per cent., but the wattless component of the current remains the same and the energy drawn from the line is 33,200 watts, neglecting minor losses. By comparing this with the 1430 watt loss in starting the same motor from an auto-transformer, it will be seen that not only is the line current reduced at the time of starting, but the actual energy consumed is less than one-half when an auto-transformer is used.

The above figures are approximate only, as the losses in the motors, transformers and the lead wires are

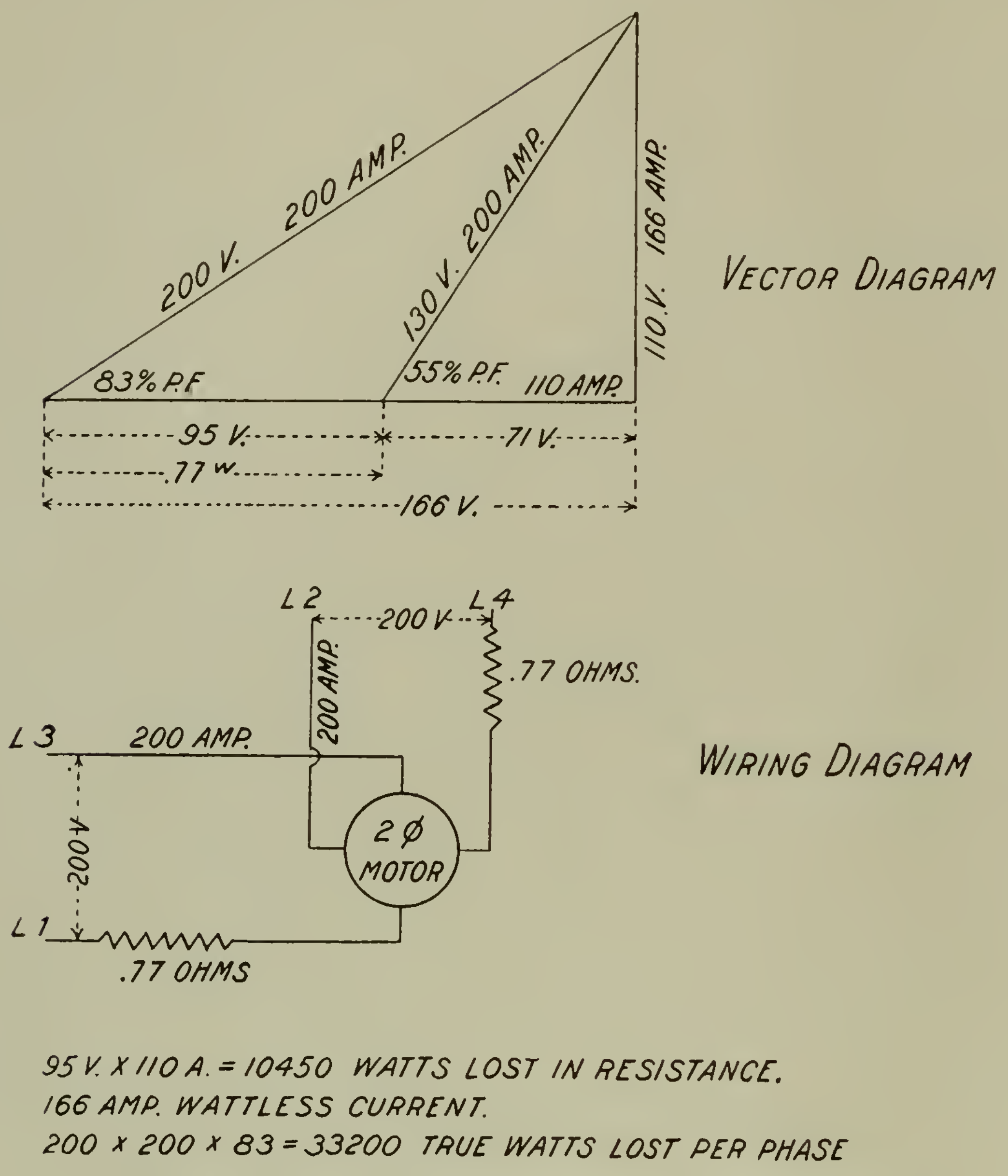


FIG. 2.—DIAGRAM OF INDUCTION MOTOR STARTING WITH SERIES RESISTANCE IN THE PRIMARY CIRCUIT

neglected. The figures, however, represent approximate commercial conditions, and the losses given are for one phase only; for a two-phase motor they will be doubled. From the above it is easy to see why all commercial induction motors are started by means of an auto-transformer, and that the use of series resistance, while it improves the power factor, does not reduce the wattless current or improve the regulation, but increases the amount of current taken and makes an inefficient starting device. In such cases as this, the improving of the power factor is a decided advantage. In fact, the power factor could be increased by this method even with an increased wattless current and decreased regulation.

Comparing these motors with the series commutator type motors with which series resistance is used for controlling, we find that undoubtedly better conditions could be obtained with an auto-transformer; but with the series motor the torque is approximately in proportion to the square of the current, so that a small variation in the current makes a considerable variation in the torque, as explained under "The Control of Direct-Current Motors." For this reason the current taken by the series motors in starting is not nearly so great as that drawn by an induction motor, and the use of series resistance for crane service, for instance, materially simplifies the control apparatus; for this reason it is used in the same manner as with direct-current motors. A voltage system of control would be somewhat more efficient, and where step-down transformers are available, such as in railway work, these series motors are controlled from taps on the transformer.

Multi-Point Auto-Starters—When starting a motor where the torque increases with the speed of the motor and the load is comparatively light, at starting, a multi-point "auto-starter" or "compensator" should be used. This enables the motor to be started with a low voltage and consequently a small line current. As the speed of the motor increases, higher voltages can gradually be applied until the motor is brought up to full speed at the line voltage.

If, on the other hand, a double-throw switch were used in connection with such an auto-transformer, only one starting notch would be available, which would materially increase the amount of current taken at the time of starting. Centrifugal pumps, fans and similar apparatus are well adapted for starting with the multi-point auto-starter, as the torque of this apparatus varies as the square of the speed, and considerable saving can be effected and the maximum current materially reduced by the use of this kind of starting device.

For motors up to 50 H. P. a starting device with three points can readily be obtained; for larger motors, six and nine-point starters are available. These starters are all of the drum type. The most approved designs have no moving wires connected to the drum, all contacts being made by fingers pressed against metal clips mounted on the drum. These fingers and clips should be removable, so that the controller can be readily repaired if the contact surfaces have been burned by arcing.

Where heavy loads are to be started which require considerable torque to overcome the static friction, but where the running friction is comparatively light, such as a long line shaft, it is necessary to apply considerable voltage to the motor terminal to start the load, and in most cases this voltage is sufficient to bring the motor up to practically full speed, so that a double-throw switch is all that is necessary. In fact, it is an advantage to apply the voltage suddenly to the motor terminal so as to jar the load loose. By suddenly applying this voltage the maximum current taken at starting can be appreciably reduced.

Where a double-throw switch is used for starting these motors, it is generally because the starting conditions are severe, and for that reason considerable current will have to be handled by the switch. Separate removable arcing tips should be provided of very rugged construction.

Recent tests made indicate that arcing tips can be provided which will open the full-load current of the switch from 1500 to 2000 times before being renewed. When a switch of this kind is used in a factory the motor is generally started but twice a day, so it will readily be appreciable that arcing tips of this character will last for several years without being renewed. This, however, does not mean that they should not be properly inspected, as sometimes short circuits occur which materially reduce the life of an arcing tip.

The use of an induction motor with a short-circuited secondary does away with all motor troubles and concentrates them at the controller. This has rendered the design of switching devices for these motors quite difficult. This problem has received special consideration, with the result that several different types of starters have been placed on the market, all of which employ an auto-transformer to reduce the line current. The application of the proper starter depends upon the load which the motor starts.

Fuses—Where fuses are used, in starting induction motors with short-circuited secondaries, the starting devices should be arranged to open-circuit the fuses in the starting position. In some cases the fuses have been short-circuited, but the resistance of the fuse is small, and where the lead wires for short-circuiting purposes are long, their resistance is considerable, so that the short-circuit is not always effective. The general method employed is to run wires from the feeders direct to the devices and use these in the starting positions. In the running position other wires are used which connect to the fuses.

Auto-Transformers—Where a two or three-point starter is used, the auto-transformers should be provided with a number of extra taps so that the starting voltage can be adjusted to suit the load. The auto-transformers furnished should be able to withstand the magnetizing current continuously, so if through accident they are left connected across the line in the running position they will not burn out. These transformers should be properly enclosed, so that there will be no fire risk if the transformer is burnt out in starting the motor.

Commercial transformers can be obtained which fulfill the above functions admirably. A very common form consists of an ordinary transformer having case-iron caps placed over each end to cover the windings, the central portion of the transformer having the iron exposed. This gives a good radiation. A burn-out test made on this type of transformer did not heat the exterior of the iron sufficiently to cause a fire risk. The heavy white smoke emitted under these circumstances is of itself a splendid warning.

Series - Parallel Control — Series commutator-type motors can be controlled by placing two motors, first in series and then in parallel, in the same manner as with direct-current motors. This method, however, is seldom used, as the varying of the voltage at the terminals of these motors can be done very readily by use of an auto-transformer. These motors can be used on both alternating current and direct current, and when operating on direct-current lines are sometimes controlled by this method.

Cascade Connections — Polyphase induction motors can have their speed varied by using two motors of the slip-ring type, the secondary of the first motor being connected to the primary of the second motor. This method is commonly called a cascade connection. The speed of the combination is equivalent to the speed of a single motor having a number of poles equal to the sum of the poles on the two separate motors. This method of control has been used in traction work and will probably be used in large industrial installations where two or three fixed speeds are required.

Intermediate speeds can be obtained by resistance in the secondary of either motor. Where the two motors are of equal power with a different number of poles three speeds can be obtained:—First, with both motors cascade giving the lowest speed; second, with the motor having the larger number of poles; third, with motor having the smaller number of poles. In each case the power delivered will be the same, provided the two motors have the same horsepower capacity.

CHANGING MOTOR CHARACTERISTIC—DIRECT CURRENT

Changing Field Strength—Changing the field strength is a very common method of controlling direct-current shunt and compound-wound motors, where it is desirable to have the speed remain constant on each notch of the controller independent of the load. Commercial motors can be obtained having speed ranges as high as five or six to 1 by this method of control.

However, there is very little demand for motors with more than a four-to-one speed variation, and even these motors represent but a small portion of the demand for this class of motor. By far the greatest number of motors are sold having a two-to-one speed range. The application of these motors has generally been made to machine tools and printing presses.

Wide variations in speed of machine tools are obtained by mechanical devices; for instance, a lathe with a 20-to-1 speed variation driven by a motor with a four-to-one speed variation would require approximately two mechanical speed changes to obtain the total range of speed. This method of control is very efficient, as the only power lost in resistance is due to the shunt field current which represents a very small percentage of the energy of the motor. The speed is practically constant on every notch of the controller independent of the load.

This control is generally effected by means of a drum-type switch which reverses the motor and provides the necessary starting notches by armature resistance. In the same frame with the drum switch is mounted a face plate which controls the amount of resistance in series with the shunt field. The control is so arranged that in the off position all of the resistance is inserted into the shunt field circuit. On the first starting notch this shunt field resistance is short-circuited; after the motor has been brought up to speed this resistance is gradually inserted in the circuit to reduce the field strength and increase the speed of the motor.

Automatic Acceleration—As the size of these motors increases, it is probable that a form of unit-switch control will be found necessary. Such a control gives automatic acceleration in starting the motor, removes all armature circuits from the hand-switching device and permits of a powerful blow-out being employed which will increase the life of the contacts. With such a control a very small master switch can be used, mounted in combination with the field rheostat. The difficulty of furnishing large drum-type controllers is due to the heavy contacts required for the main line current. This makes the controller difficult to operate, particularly when the contacts are partially burnt and have become rough.

Changing the Number of Armature Conductors in Series—As the speed of the motor, other things being equal, depends on the number of armature conductors in series, efforts have been made to vary the speed of the motor by changing the arrangement of these conductors. The most common method employing this principle is the double commutator motor. The difficulties experienced seem to be confined to the design of the motor itself.

The objection to the double-commutator motor, other than that of its cost, is the difficulty of balancing both sections so that the two ends can be run in parallel. The controller for this motor is a combination of the series-parallel control with field rheostat for obtaining the intermediate speeds.

Changing Number of Poles—Changing the number of poles is a very effective way of varying the speed of a motor. At the same time, however, it varies the power the motor can deliver and adds other complications. The writer does not know of any practical application of this principle for a direct-current motor.

ALTERNATING CURRENT

Two-Speed Induction Motor—The polyphase induction motor is furnished with two sets of poles, one set generally having twice as many poles as the other set. These are known as the two-speed induction motors and have been used in a good many cases. The control generally consists of a standard auto-starter and a double-throw switch for effecting the change in the number of poles. This method of control has been applied, in general, to motors with short-circuited secondaries.

In one or two instances such motors have been built with slip-ring secondaries in which external resistances are furnished. This type of motor, however, is exceedingly complicated, as the secondary must be provided with a double winding corresponding with the double sets of poles in the primary. For this reason these motors have not been developed.

With a motor having two sets of poles care must be taken in passing from the high-speed to the low-speed combination. If the motor is running on the high speed and the connections are changed to low speed, a dynamo action is set up and the torque of the motor is reversed in the same manner as in changing the voltage across the terminals of a direct-current motor operating on a multi-voltage system.

This dynamo effect is very severe, and proper precaution should be taken to protect the apparatus from mechanical strains. The usual method of changing the speed of such a motor is to open the switch which changes the number of poles and allow the motor speed to drop to approximately slow speed before the switch is closed on the slow-speed side.

Alternating - current single - phase motors can be controlled by introducing resistance in shunt with the field. Owing to the good design of these motors, considerable variations in speed can be obtained in this way without interfering with their commutation.

MECHANICAL DEVICES

Gearing, clutches, etc., are generally used in connection with motors whose speed is changed by changing their field strength. The old method of controlling the speed of machine tools was done entirely by mechanical means and generally gave few steps with wide variations in speed between steps.

Two or more motors have been used for obtaining different speed variations in the same piece of apparatus. Probably the best known application of this method is that made to printing presses of large size, and known as the Kohler system, in which a small motor is used for operating the press at the slower speed, and a larger motor for the high speeds.

The control for such a system generally consists of a panel on which is mounted various switching devices controlled by solenoids. This control can be operated from a number of stations by means of a master switch or a series of push buttons. The mechanical connection between the machinery and the slow-speed motor is made by means of a clutch, so that the low-speed motor can be disconnected from the system at the higher speeds.

Two types of motors have been placed on the market in which the gap between the armature and the field poles is varied. In one of these the iron of the field poles is withdrawn by means of mechanical gearing. In the other type of motor the armature is moved parallel with the axis of the shaft. Both types require mechanical devices for balancing the magnetic pull on the parts which are moved. At present the application of this device has been quite limited.

In a number of instances centrifugal devices have been used for starting motors. One application consists of a single-phase induction motor, which is started up as a repulsion motor and the connections changed to an induction motor after the speed has reached a fixed limit.

Another application of this principle is entirely mechanical. The single-phase induction motor is started light; after it has attained considerable speed the centrifugal device grips the pulley to which the load is belted.

BRAKES

Two general methods of braking or stopping an electric motor have been employed, and as their operation depends largely upon the controller, they should be considered as a part of the control system.

The dynamic brake consists in short-circuiting the armature through a suitable resistance, either having the series field in the circuit or having a shunt field excited from the line. The principle consists in making the motor operate as a generator. The load consisting of the internal resistance of the motor and whatever external resistance is used.

Shunt motors are very often used in this way and are very reliable. The shunt field is excited either by the motor electromotive force or is left connected to the line.

A mechanical brake is generally released by means of a solenoid and applied by a spring or weight. Shoe, band, and disc brakes are used and each has its particular advantage. All three forms can be made to operate satisfactorily by careful design. At the instant of application the stored energy of the moving parts causes the brake to grip the wheel with considerably more than the normal torque. In some instances this excess torque is two or three times the normal. In properly designed brakes the stored energy of the moving parts is compensated so the shaft does not receive excessive strains.

Where brakes are used often, the energy absorbed by the brake causes excessive heating unless proper means are provided for radiating this heat. The problem is the same as the heating of electrical machinery, although the mechanical parts of the brake may be run at a very high temperature provided the magnet coil is kept at a low temperature. The temperature of the brake itself is only limited by the material of which it is made. For instance, organic substances will deteriorate at 100 to 150 degrees C., while the cast-iron shoe of a railway brake can be run 200 to 400 degrees C.

METHODS OF REDUCING THE LINE CURRENT AT STARTING

Very often the consumer finds after the motor has been installed that the starting of this motor causes considerable drop in the line voltage, and the question naturally arises, in what way can the starting conditions be improved? Following is a table giving in a general way different methods which may improve the starting conditions of the motor. Any improvement depends entirely upon the condition of the load, the characteristics of the motor and the type of starting device or controller that is already in use:—

1. Increasing the number of steps.

2. Jarring the load loose, by suddenly applying the power.

3. Increasing the field strength. (Compound winding.)

4. Ilgner system. Using a motor-generator set with a heavy fly-wheel.

5. Substituting automatic acceleration for hand starting.

6. Starting the motor light and using a clutch to pick up the load.

7. Substituting an auto-transformer for a rheostatic method of starting alternating-current motors when the control is in the motor primary.

8. Increasing the number and decreasing the size of the motors.

9. Increase the slip of an induction motor.

These methods have all been discussed in the previous part of this paper and will not be dealt with here.

APPLICATION OF MOTORS AND CONTROLLERS

In the following the different applications of electric motors have been taken up and the types of controllers applicable for the different service conditions have been noted briefly. The treatment has necessarily been general and can cover only a few of the many applications of motors for industrial purposes. The methods of control noted are explained in the early portion of the paper.

CRANE

The controller should be arranged for remote control by bell crank and levers or master switch. The handle should have a reciprocating motion. The controller should be narrow.

Direct Current — Series motors should be used, controlled by resistance in the armature circuit. The torque is proportional to the current. A series brake coil is used, so no brake switch is required. The unit-switch type is advisable for heavy service where few steps are necessary.

Alternating Current — A single-phase series motor is used, controlled by armature resistance similar to a direct-current motor, with a shunt brake coil, and separate brake switch.

HOIST

The controller should be protected from the weather. Automatic acceleration is often desirable. An automatic stop at the top and bottom limits of travel can be arranged as in elevator work.

Direct Current—Series motors are used where the hoist is always under load, and compound motors where the load is lowered and the motor is apt to run away. The control is by armature resistance. A dynamic brake can be used with compound-wound motors.

Alternating Current—Slip-ring induction motors are controlled by resistance in series with the secondary. This motor has a fixed speed limit and is controlled like a direct-current shunt motor.

CENTRIFUGAL FANS

Direct Current—Shunt motors are used and controlled by both armature resistance and shunt field variation. The torque and current decrease approximately as the square of the speed, so the power absorbed in armature resistance is small.

Alternating Current—Polyphase induction motors are used with resistance in the secondary circuit. The loss is the same as with direct-current shunt motors having armature resistance. Automatic devices for starting have not yet come into use.

PUMPS

Plunger pumps have constant torque and heavy starting conditions. The loss by armature resistance control is directly proportional to reduction in speed, therefore field control is preferable.

With centrifugal pumps the power is inversely proportional to the head, so the speed of the motor should be reduced when the head is reduced. The torque varies approximately as with a fan.

Automatic starting devices can be obtained for small constant-speed, alternating-current motors and all direct-current motors.

PRINTING PRESSES

Direct-Current Shunt Motors—The control has automatic overload and no voltage release and push-button release. The power is proportional to the speed. The slow speeds are obtained by low voltage from a small motor-generator set (Teaser system); higher speeds are obtained by field control. One motor-generator set can be used for several presses.

Controlled from a two-voltage three-wire system, the slow speeds are obtained by armature resistance and the higher speeds by field control.

Kohler System—This system was described under "Mechanical Devices."

MACHINE TOOL—DIRECT CURRENT

Shunt and Compound-Wound Motors—The control is obtained by varying the field strength. A four-to-one speed variation can be obtained on one voltage. A simple drum-type controller is used for reversing the motor and providing the starting notches. A face plate mounted in connection with the drum inserts resistance into the field circuit. No automatic attachments used at present, but this control will probably develop into automatic acceleration for larger motors. The resistance for the field should be adjustable to suit conditions, especially for compound-wound motors.

The multi-voltage control, in addition to the features mentioned above, should have an automatic device to insert resistance into the armature circuit in passing from one voltage to another, especially when coming quickly to the off position, it has fewer steps by field control.

MILL TABLES

Generally Direct Current—For this service series or compound-wound motors, designed for quick reverse and controlled by resistance in armature circuit, are used. Both motor and controller must withstand severe usage. The controller handle should have a reciprocating motion. For large motors a unit-switch controller should be used, operated from a master switch and adjusted for quick action.

MILL ROLLS

For three-high rolls, both alternating-current and direct-current motors are suitable. These motors are mounted on the same shaft with a very heavy fly-whel, and their speed is adjusted so the fly-wheel will take the peak of the load.

For two-high rolls, direct-current motors only are applicable; some form of motor-generator system of control will probably be used, but such an outfit has not yet been installed.

MISCELLANEOUS STEEL MILL CONTROLLERS

Alternating-current induction motors are generally used for constant-speed work controlled by an auto-starter. For variable speed both direct-current series and compound-wound motors are used, controlled by resistance in the armature circuit.

COTTON, WOOLEN AND SILK MILLS

The alternating-current polyphase induction motor is used entirely, because of the fire risk due to lint. In the case of group drive, the control is by auto-starters or secondary resistance, preferable exterior to motor. The controller must be entirely enclosed and dustproof.

The individual drive by small motors thrown directly on the line is being developed and will be used considerably in the future. The absence of line shafting and belting materially reduces the fire risk and repairs.

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Leading Articles

The Electrolysis of Rails

IN connection with the electrolytic action of the return current from overhead trolley systems, we are accustomed usually to hear only of the destruction of the water and gas pipes adjacent to the tracks. It is therefore interesting to note that there are cases in which the electrolytic action has resulted in damage to the rails themselves.

Elsewhere in these pages, S. H. McLeary tells of the destruction of rail flanges and spikes on an electric line in Porto Rico, where the moist condition of the soil was particularly favourable to electrolytic action. There can be no doubt that the escape of the return current from the rails to the spikes and into the ground is responsible for the results shown in the illustrations. Given a moist soil, with the rails positive to the ground, and the conditions for electrolysis are fulfilled.

A similar action was noted by A. A. Knudson in a paper read at the October, 1898, meeting of the American Institute of Electrical Engineers. Of a number of tests made in different parts of New York City to detect stray railway currents, one was on trolley tracks terminating near an elevated structure. Gas and sewer pipes were buried in the adjacent ground.

The maximum reading obtained with a voltmeter between the rails and the elevated pillar or between the rails and the sewer or gas pipes, was 10 volts, the rails being positive to the other points. When the rails were taken up, it was found that quite a large amount of metal had been removed from them by electrolysis. The flanges were cut down to knife edges for several feet back from the ends, the edges being irregular and somewhat jagged in appearance.

Nearly all the tie rods also were so eaten away that the middle part was missing, the ends protruding from the rails from 6 to 12 inches. The ridges and pitting, characteristic of electrolytic action, were plainly visible.

Some astonishment was expressed that the tie rods should be destroyed to such a greater extent in the middle. The reason assigned for this, however, was that the ground wire was placed midway between the rails and a few inches below the rods. The escaping current would thus pass from about the middle of the rods to the ground wire—the rods and rails being positive to the earth and the pipes—and the excessive cutting at this part of the rod would be accounted for.

On another occasion, Mr. Knudson found that the chairs for supporting street railway track were attacked. The chair legs, which were spiked to the ties at their base, were in contact with moist earth both outside and inside, making a convenient outlet for the current from the rails to earth and water mains. The metal was corroded to a great extent, particularly around the spike heads.

It will thus be seen that there is nothing essentially new in what Mr. Leary describes, though this particular manifestation of electrolytic action may be somewhat novel.

Switchboard Locations

THE proper location of the switchboard in the railway or other power plant is a matter of no little importance, and the diversity of practice which may be seen in different parts of the country is good proof that the subject has not always received adequate consideration on the part of designers. After a switchboard has been erected in a plant, it stays in place, in ninety-nine cases out of a hundred, as long as the plant exists, and it is therefore exceedingly worth while to plan for the future in solving this problem. Cases have occurred where the only expansion of the switchboard which was possible was around a right-angled corner at the end of an engine room, or by building a gallery over the established installation—an inconvenient and unsightly arrangement in either instance. The switchboard should parallel the axis of a plant's ultimate development.

The switchboard should always dominate the entire operating room, and yet its equipment should be as little in the way of crane movements as is possible. If these two points are observed, the problem is solved. In some very large recent plants, the principal switch mechanism is installed in a fire-proof room, separated from the engine or turbine installation; this is good practice if the operating room is overlooked by an attendant with remote control apparatus at his fingers' ends, including the essentially important instrument leads.

Many years ago capable engineers grasped the fact that the switchboard is the brain of a power plant, and nothing in the way of switch mechanism development justifies any other view of the matter. Unless the switchboard is concentrated at the operating focus of the plant's machinery, the chance is taken of incurring great inconvenience and possible disaster in the times of sudden emergency which come to every commercial installation.

Small Engines and Motors

In an interesting paper on "Small, Vertical High-Speed Engines," recently read before the Detroit Engineering Society, F. R. Sill discussed the principal defects in the design of these prime movers and pointed out the characteristics of the most advanced types of such equipment thus far developed. The small engine has certainly made good progress toward reliability of operation, and it is not uncommon to run across machines of this type which will run three or four months without requiring any attention, either to the oiling system or for adjustments, except the filling of the sight-feed cylinder lubricator.

In the field of forced draft applications, where the engine's exhaust steam is turned into the heating system, the small vertical or horizontal unit of from 3 to 10 H. P., and sometimes higher, has an undoubted usefulness; but after all is said in favour of the small engine, it is impossible to escape the conviction that the electric motor is vastly superior to it except in a very few unusual cases.

Surely in point of reliable operation the electric motor can equal or exceed anything which a small engine can do. Innumerable instances may be cited where an induction, or even a direct-current, motor has operated in continuous service for many months without the slightest adjustment. The space occupied by a motor of equal size is always less than that needed by an equivalent engine, and the first cost of the latter is easily greater, while the labour of installation is much less in the case of the motor. A 3 H. P. induction motor wound for 220 volts, 60 cycles, three-phase current, can be purchased for about $65 at the factory; whereas a first-class vertical high-speed engine of that size, with a 3 by 2½-inch cylinder, costs about double this sum, or $117, to cite a recent quotation.

As the size of the engine increases, the costs draw nearer, until in the 10-H.-P. machine of either type there is not very much difference in selling price. Among the myriad of applications of small engines and motors, it is probable that the majority of the machines in present-day service do not exceed 5 H. P., so it is safe to say that the engine for small service can hardly be built in the same quality for as little money as the equivalent motor.

In point of ability to withstand heavy overloads, the small motor easily comes off victor, and it is no slight matter to escape the burdensome heat which the use of a steam engine entails even under favourable circumstances. Mr. Still points out in his paper that, by reason of improved designs, the steam consumption of the small vertical high-speed engines per horse-power-hour has now been cut down from 60 or 80 lbs. to about 37 lbs. in a 6 by 6-in. machine operating at 500 revolutions per minute and full load with 100 lbs. pressure

This is a great gain in economy, indeed, but in all-around service at fractional loads, normal rating, and overloads, it is hard to see how the small motor can be beaten on the economy question, if the cost of power is anything in reason. Even allowing full-load conditions and an evaporation of 8 lbs. of water per pound of coal, with coal at $3 per ton, the fuel cost alone of operating such an engine as the above would be close to three-quarters of a cent per horse-power-hour, — a figure which can certainly be bettered in a first-class electric plant.

In actual variable service, the cost of power per horse-power-hour in a small vertical steam engine would run nearer three or four cents, taking standby losses into consideration, and including maintenance expenses. Fan work is on a par with pumping in its favourable conditions, but in most other applications of small power it is difficult to see why anyone should choose an engine if a motor can be secured to do the required work. Mr. Still's paper in no sense recommended the use of small engines in competition with motors, but it is impossible for an advocate of electrical methods to read it without commenting upon the ease with which the small motor meets all the requirements which are set forth therein as having been achieved after arduous work by the small engine designer.

There is no doubt that the speed of a small engine can be more flexibly controlled by throttling the steam supply than that of most motors now in stationary service, but recent improvements in "inter-pole" types of motors, as investigated experimentally and commercially by the principal electrical manufacturers, bid fair to meet any requirements which the steam engine has pre-empted in years gone by.

Apprenticeship Course as a Preparation for Engineering Activity

In an address delivered to the engineering apprentices of the Allis-Chalmers Company's electrical works at Cincinnati, on August 30, Prof. V. Karapetoff, of Cornell University, said that the three essentials for a successful engineer were professional knowledge, knowledge of business forms and of human relations, and strong character.

As regards professional knowledge, the construction of machinery, the manufacturing operations and testing may be learned in the works without a particular effort. However, the question "Why?" is of decided importance; one should not be satisfied with "How?" The habit of analyzing should be acquired.

To get the full benefit from the factory work, regular notes should be kept of the work, sketches made, a separate sheet kept for doubts, to be straightened out at a future opportunity, and rough check calculations should be made on the machines worked with.

In addition to this, the apprentice should devote a part of his evenings to systematic study, reading at least one electrical magazine and keeping an index of at least one subject in which he was interested; college books and notes should be gone over to make sure of fundamentals. He must be absolutely sure of Ohm's law, the general law of induction and its application to machinery, the law of electrical energy; the general theory of direct-current and alternating-current machinery and transformers should also be known.

The apprentice should gradually

familiarize himself with the standard electrical books. He should select some one branch of electrical engineering and devote all his extra time to it. Every opportunity for an original investigation should be seized.

Human relations and business forms should be studied, as without a knowledge of these it would be impossible for one to hold a responsible position. Observe the characters of men you are working with; in particular the influence of age, education, nationality, and the like; also things that make them successful, things that are an impediment in their work, things that they would like to have, things that make them happy and unhappy, and betterment work that they would appreciate.

The foremen should be observed, and their ways of conducting their departments. The apprentice should make clear to himself what he would consider an ideal foreman. Do not judge the foremen by the way they treat you.

Observe the general factory system as far as possible. In particular, gradually find out the following:—

General sub-division of duties of the executive officers; the management, commercial, engineering, manufacturing, erecting, selling department, etc.

Arrangement of factory buildings, and the general idea of this arrangement.

Orders, cost, accounting, etc.

Causes of waste of time and materials, and possible remedies.

Get a thorough understanding of the significance of co-operation in modern industry. Do not get rusty in regard to general life questions; continue reading books on philosophy, economics, history, and the like. This will make human relations clearer. Besides, a man in a responsible position must be a well-educated man; he should be posted on many general things and ought to be able to speak about them.

Engineering and business knowledge are the necessary conditions for usefulness ("success" and usefulness are not always the same), but the proper development of the character is the third necessary condition. What is the use of having a profound engineering knowledge if one have not the necessary perseverance to achieve results; or to have a knowledge of business forms and relations, if one's temper be such that nobody cares to be associated with you in business?

Practice daily the qualities of the character that you find essential for a good citizen and good business man. Work patiently on any problem until a result is achieved. If it should be impossible to get satisfactory results, at least make clear to yourself the causes and limitations.

Be honest in all things; do not be afraid to confess your mistake or ignorance. Train your character by doing over your work cheerfully. Keep down your selfish personality and ambition. Do not let them interfere with your business. The highest form of personality and ambition is to have your part of the work done in the most ideal way.

Be generous, polite and considerate to others; there are no circumstances where you would be justified in breaking this rule. Remain dignified even under unjust reproof. Remember that you work for the future; shape it aright now, and it will come as you expect it to be.

Gas and Electric Lighting Industries Compared

In a report on Electrical Industries in 1902, recently published by the United States Bureau of the Census, some interesting comparative figures are given of the gas and electric lighting industries.

Because of its rapid development, electric lighting has already been placed in sharp competition with other means of artificial illumination, and with one of these, namely, that depending upon the manufacture of gas, it can be compared. The gas industry in the United States is nearly a century old, dating from 1806, whereas central electric stations have been in existence only about twenty-five years, or since 1879, when two or three were to be found in limited operation. The latest available comparative census statistics for the two industries are shown in the following statement:—

COMPARATIVE SUMMARY OF CENTRAL ELECTRIC STATIONS AND GAS PLANTS

	Central Electric Stations, 1902	Gas Plants, 1900
Number of establishm'ts.	3,620	877
Cost of construction and equipment	$504,740,352	*$567,000,506
Cost of supplies, materials and fuel	22,915,932	20,605,356
Salaried officials and clerks:		
Number	6,996	5,904
Salaries	$5,663,580	$5,273,500
Wage earners:		
Average number	23,330	22,479
Wages	$14,083,112	$12,436,296
Income	85,700,605	†75,716,693

* Capital. † Value of products.

While these statistics for the two industries do not cover the same year, the periods reported correspond sufficiently for a general comparison. The totals shown for central electric stations exceed those for the manufacture of gas in all the items except the "cost of construction and equipment," which is compared with the capital required for the gas companies. The capital stock and funded debt reported for the 2049 central stations owned by corporations amounted to $627,515,875, and would possibly be the better total to compare with the capital reported for gas companies, namely, $567,000,506.

The income for the central electric stations was $85,700,605, while the value of the gas products was $75,716,693.

It is true that in order to give full credit to the electric lighting industry it would be necessary to include the figures for isolated plants, which are usually assumed to be about equal to the central stations as regards extensiveness of equipment. These stations, however, would be offset by a large and unknown number of isolated gas plants.

The following table gives the relative distribution of the central electric stations and gas plants in cities of different population, and is very interesting in its revelation of the wider spread of electric stations:—

NUMBER OF CENTRAL ELECTRIC STATIONS AND GAS PLANTS IN PLACES CLASSIFIED BY SIZE

Population of Places in Which Located	Central Electric Stations, 1902	Gas Plants, 1900
Under 5000	2,714	200
5000, but under 25,000	675	484
25,000, but under 100,000	128	124
100,000, but under 500,000	73	39
500,000 and over	30	30
Totals	3,620	877

In connection with this table it may be stated that in the United States in 1900 there were 827 cities and towns in which one or more gas plants were in operation, while in 1902 there were central electric stations in operation in all but 153 of these places. It will be observed from the table that 75 per cent. of the central electric stations and 22.8 per cent. of the gas plants were in places of less than 5000 inhabitants.

This, however, does not reveal the full extent of the benefit conferred by electric methods, the area of distribution from gasworks being necessarily limited by physical and economic considerations, so that one gas plant cannot supply more than three or four communities, while the electric lighting station can, and often does, supply light, heat and power to many towns and villages scattered over many square miles of territory.

The single-phase alternating-current system of electric traction is to be used on a part of the Midland Railway Company's line in England.

High-Efficiency Lighting Units in Ohio

PAPERS READ AT THE RECENT CONVENTION OF THE OHIO ELECTRIC LIGHT ASSOCIATION

Nernst Lamps

BY A. N. COPE, OF THE COLUMBUS (O.) PUBLIC SERVICE CORPORATION

THE word "progress" and the term "high efficiency" in the subject matter, form the text of this paper. The unit of high efficiency with which the writer is most familiar is the Nernst lamp,—and that his company has made progress with this unit in the city of Columbus is in evidence on every hand.

General progress is not conditioned upon high efficiency alone, as is illustrated by the facts that the more efficient Cooper-Hewitt lamp and the high-efficient arc lamp lack something which limits their field of usefulness and consequently their general progress.

The object of this paper is to give the writer's practical experience gained from the operation of Nernst lamps in a commercial field and show that, while the Nernst lamp has made progress, this success has not been due to the high-efficiency feature alone, and also to show that the central station has participated in this progress.

In the face of strong competition, electric or gas, or both, progress is made only by study,—studying the needs of your customer and the needs of your service.

The Nernst lamp proposition was presented to us in the fall of 1904, and in December we put on our circuits a trial installation which proved a failure and was ordered out by our customer after sixty days, and arc lamps put back. This was during our constructive period, and we were conscious at that time that our regulation was none too good and our knowledge of the needs of the lamp about the same. While this installation was occasionally very pleasing, it was a novelty, and we had frequent calls for the lamp.

If we could secure a new customer from our electric competitor or replace gas, we made the installation, but refused to change any of our existing installations. When any of our customers wanted Nernst lamps we referred them to our first experience.

This was our attitude until April, 1905. In the meantime, we were improving our regulation, receiving good and bad reports from the lamps and more demand for them. We then adopted the lamp as our sole means of securing business from gas users along our lines, and, in justice to the Nernst lamp, the writer must say that it has proved itself a business getter in this field.

While the company can claim no great honour or distinction for the great number of gas arcs that it has consigned to everlasting perdition, we know that it has reduced the gas company's revenue in a number of places.

The writer feels that with the campaign of education that is being pushed in Columbus, the public will consider heat value of less importance than health, and when they do our gross receipts will be larger.

It was not long before some of our arc customers began to be urgent in their demands for Nernst lamps. This was a serious problem for us, as it meant a double investment; our arc lamps began to accumulate in our store room. This condition was relieved by an arc exchange deal which we were able to effect with the manufacturers of the Nernst lamp.

The high-efficiency feature of the Nernst lamp has been an aid in keeping disgruntled customers on our lines. The quality and distribution of light from the Nernst lamp has allayed chronic kickers, even though their bills were not reduced, and those among our customers who were good light users with arc lamps are giving us more revenue from a less connected load, as the following list of installations demonstrates.

This list shows installations in different kinds of business rooms comparing their kilowatt consumption for June of 1905 with arc lamps, and that for June of 1906 with Nernst lamps.

The average kilowatt-hours return per kilowatt connected in the above list is 70.47 for the arc, while for the same unit in Nernst it is 84.75 kilowatt-hours, or 20 per cent. more, showing that 16⅔ per cent. less connected load with Nernst lamps than arc lamps, gives the same revenue, with the additional benefit of an increased power factor. It also means an increase in burning hours and a better station load factor.

Business	Arcs, Kilowatt	Consumption	Nernst, Kilowatt	Nernst. Consumption
Dry goods.....	2½	81.2	1.760	44.2
Clothing	11	892.0	9.856	825.0
Book store ...	2½	55.2	3.168	67.6
Grocery	2	25.0	1.056	34.3
Cafe	2½	217.0	2.288	308.0
Grocery	2	41.6	1.584	44.0
Saloon	2	375.0	2.464	571.0
Shoe store.....	1	53.0	2.112	160.0
Jewelry store..	1	18.0	.792	37.5
Grocery	1	87.9	1.584	102.0
Candy store...	2	233.1	2.640	289.93

The customer uses the light because of its quality and cheapness, as he knows it is to his advantage to have plenty of light that is free from offensive glare and not tiring to the eyes. This is where the central station makes progress with the Nernst lamp.

The high-efficiency unit is not a revenue destroyer, providing it has other attributes conducive to longer burning hours. The Nernst lamp has these attributes, and the flexibility, as to different sizes of units, is so suggestive that often a small lamp is placed where otherwise no light would be used.

It has been surprising to the writer to see the readiness with which the laity appreciate this flexibility. The merchant is conscious of having a variety of lighting needs, and with quick familiarity calls for 6-glower lamps here, 3-glower lamps there, and 1-glower lamp somewhere else.

This is a condition for progress, yet it is impossible to please all the people all the time, because some cannot please themselves. While good store illumination is a profitable luxury, if supported by square dealing and courteous treatment, yet there are those who will over-indulge, or have a weak link in their chain of success. Complaints we are bound to have, and it behooves the lighting company to again study how best to handle these complaints. With the Nernst lamp it is an easy matter to drop out a glower in each lamp and reduce the current consumption 25 to 33⅓ per cent. and retain the good-will of the kicker.

A feature with the Nernst lamp

that must not be overlooked is, that with the same current density as in the 110-volt circuit, twice the amount of watts may be distributed, or the same energy with one-half the drop,—a decided advantage in over-loaded circuits in old installations. It is a panacea for unbalanced three-wire distribution.

The Nernst lamp requires diligent, careful and constant care. It is not advisable to entrust them to the care of an unskilled attendant and expect good results. They do not require a high-priced man, but one who will be a close observer and study the lamp and the conditions,—this is the man who can tell you what your regulation has been since he was last over the line. After he gets acquainted with the line he does not need a voltmeter to tell how the voltage runs, and these indications are of more value than voltmeter readings taken at periods of light loads. The lamps are defective in this point,—that it is too hard to get at the ballasts to see their condition.

The system of maintenance will depend upon the number of lamps installed. With a small number it will pay to do some of the repair work on the customer's premises; but, as the installations increase, it is well to have extra holders to replace defective ones, and these, in turn, to be repaired at the stock-room during the repair man's leisure, or by some one assigned to this work. A maintenance system which records time and material on each installation indicates by the number of ballasts burned how well the glower voltage is adapted to the line voltage. The right kind of maintenance man gets his glower instruction from the ballast condition.

While mixed installations afford us little opportunity to get accurate data on Nernst maintenance, on the whole we are satisfied that it is not high. From accurate records kept of some of the largest installations, the writer finds the cost varying from 0.48 cents to 0.69 cents per kilowatt-hour. This cost will vary directly as the regulation and the care of the lamp.

Since April, 1905, we have installed nearly 6000 glower units, 1200 of which represent 300 alternating-current arc lamps successfully replaced by 300 4-glower Nernst lamps, the balance being new business.

In conclusion, the writer wishes to say that he firmly believes that had the electric competition been less keen, central station "conservatism" would have had less general progress of high-efficiency lighting units to report.

The GEM Filament Lamp

BY C. C. COLLINS, COLUMBUS, OHIO

ALTHOUGH great improvement in the application of electricity for lighting purposes has been made in the past ten or twelve years, it has been only a short time that we have had any material increase in the efficiency of the lighting units themselves. The arc lamp remained stationary, so far as efficiency was concerned, while the incandescent lamp was bettered but little, if we take into account its comparatively short life when burned at a higher voltage, and, therefore, a higher efficiency.

Recent improvements, however, have taken place all along the line. The flaming arc, Nernst lamp and Gem filament incandescent lamp are probably the most notable of the improved units which are commercial. This paper will be confined to the last, namely, the Gem filament lamp.

Improvement in the incandescent lamp must be more welcome than that in other units, since it constitutes, in nearly every case, the greater portion of the central station's load and source of revenue. Although there are still some central station managers who cling to the lower efficiency lamps, fearful that should a better lamp be substituted the revenue would be irreparably reduced, to continue to serve to its patrons such inferior articles is only to invite discontent, competition, and perhaps legislation. Invariably, to lower the price of a commodity is to increase its consumption.

The writer has found that if a customer is, with the same expenditure, able to increase his lighting, and, therefore, outshine his neighbour or competitor, he is willing to spend even a little more than before for this form of comfort or advertisement. The neighbour or competitor follows the lead, and so the game goes on to the benefit of the central station, which is able to supply good light at cheap rates.

The writer does not believe that any community has been worked so hard that it is impossible to further increase the lighting. Further, it is possible with existing installations to substitute a lamp of higher candle power, but consuming the same amount of energy. With this the consumer gains and the central station not only loses no revenue, but gains a satisfied customer.

What is more unprogressive than a poorly lighted store or house and a dissatisfied, grumbling customer, who feels hardly able to pay the light bill, from which he derives so little benefit, and who has been at other places which were brightly lighted, and yet the cost was very little, if any, greater than his? It would be ridiculous to attempt to keep your customer in ignorance of improvements in something which he has found necessary, only because you feared that should you give it to him your income would be reduced. No improvement is too good for your customer if you would retain him when reverses set in in the way of competition with other as well as electrical illuminants.

This new incandescent lamp, as it is offered to us, resembles the older 3.1 and 3.5 watt lamps, but its filament has been so treated that it can be burned at higher voltage, and, therefore, higher temperature, without a material reduction in its life. Just how this is done is a factory process which concerns the central station very little. What does concern the central station is its feasibility.

A radical departure is the factory marking of the Gem lamp in that it has three different voltages and one wattage on the label. The wattage, of course, shows the size of the lamp, while the three voltages are given to instruct the central station as to which lamp should be ordered, so as to secure a lamp whose life will be the same as the 3.1, 3.5 or 4-watt carbon filament lamp. The central station which buys the lamp whose top voltage corresponds to that of its circuit, will secure a 2.5 watt efficiency, while the others will secure only a 2.65 or 2.8 watt of efficiency.

This departure is beneficial in several ways. It combines all efficiencies in one lamp and does away with the term candle-power in soliciting business from your customer. It has so long been the custom of the merchant to judge the amount of light he is getting by reading the lamp labels or believing the not always truthful solicitor, this method of marking now opens up an avenue for soliciting which heretofore was practically unknown. It leads to the selling of useful light rather than candle-power, of which the average person knows very little.

It is essential that the solicitor should always gain the confidence of the customer sufficiently that he be permitted to lay out the system of lighting for him, telling him only what good light for his house or store will cost him. It is then the duty of the solicitor to select units of such size and so place them that the customer gets the greatest amount of useful light for the least expenditure.

In working along these lines, it should never be the object to deceive the customer in any way. All methods of measurement should be explained to him in the simplest way possible, a matter not very difficult for an expert solicitor.

Direct comparison of illuminants is probably the best method of convincing the public of the advantages of one illuminant over another. This can be done either on the customer's premises or in a display room owned by the central station. By this method all the effects of reflectors, globes for filtering out objectionable colours, general diffusing properties, etc., can be taken into full account. The customer is now buying light, not candle-power, nor kilowatts, and can see for himself if one illuminant has advantages over another. A display room owned by the central station can in such cases be made invaluable.

The effects of all reflectors and globes must be taken into account and the real value of the light to the customer shown. All modern methods of lighting use reflectors or globes of some sort, and great care should be taken in the selection of these reflectors.

The high-efficiency unit or Gem lamp and its shade must be used together as a unit. It is generally used with one of two shades, the concentrating and diffusing. These shades are so designed that they give an even distribution of light over a specified area, a most desirable feature. Thus the lamps can be spaced so as to give a very even distribution of light over a whole room or floor.

The efficiency of the Gem lamp at top voltage is 2½ watts per mean horizontal candle-power, but when used with its shades a much higher efficiency in useful light can be obtained, the candle-power becoming 140 per cent. and 240 per cent. of the mean horizontal candle-power. This is far better than has ever been attained heretofore with the incandescent lamp, and is partly due to the excellence of the shades used. Another most important feature is that the source of light is distributed over a much larger area than with the arc lamp, Nernst lamp and flaming arc, when used at their maximum efficiency, that is, without dense globes.

A concentration of the source of light has sometimes a misleading effect on the merchant who is buying light for his store, especially if he looks at the lights themselves and judges their respective light-giving powers by their brightness. He very seldom stops to consider that if the source of light be small it must be intensely bright in order to equal the illuminating power of a lamp in which the source is distributed over a larger area.

The Gem lamp in large size is found to fill a long felt want for something between the arc and ordinary incandescent, which position it fills admirably. Although not equal to the arc in efficiency, it is far more suited where ceilings are low, and in every case where clusters are now used.

A cluster of five 16-candle-power lamps of the ordinary 3.1-watt type would consume 250 watts and give 80 candle-power, while the 250-watt Gem lamp consumes the same energy and gives 100 candle-power. And besides giving more useful light, a renewal for the Gem lamp would cost 64 cents, while five 16-candle-power lamps would cost 82½ cents.

The cost of installing the Gem unit is less than its equivalent in candle-power of 16-candle-power lamps or Nernst lamps, costing 94 per cent. of a cluster of 16-candle-power or 16 per cent. of a Nernst lamp. The central station which is obliged to make free installation of lamps will not find it necessary, should this unit be displaced by a still more efficient unit, to write off any heavy fixed charges, as would be the case with the arc or Nernst. We thus have an efficiency, although less than the arc, equal to the Nernst lamp and better than the 3.1-watt incandescent, and a life equal to the 3.1-watt and an installation cost less than any other unit. The renewal cost is slightly less than its equivalent in 3.1-watt 16-candle-power lamps and about 75 per cent. of that of the Nernst.

The ability to install the Gem unit without any change in an existing installation is one of its strongest points and a considerable expenditure is avoided. A customer is, therefore, able to increase his lighting with no additional wiring.

Considerable difficulty was at first experienced in procuring fixtures suitable for the Gem lamp, but at present a number of companies are making such fixtures at a very reasonable price.

This lamp, to secure the best results, should hang vertically. The distance of the lamp from the surface to be illuminated should be the same as the distance between lamps, if an even distribution is desired.

All incandescent lamps should be used with shades, and their selection is a matter of considerable importance. The principal object of the shade, aside from its giving the fixture an ornamental appearance, is to distribute the light in quantities such as is desired. The shades used with the Gem lamp do this admirably. They are so formed that only enough light to prevent the ceiling from appearing dark passes through them, while the rest of the light is evenly distributed horizontally under the lamp. A wide difference will be found in shades in respect to their evenly distributing the light and absorption.

The arc lamp, preferably the direct-current type, should be used where it is essential to show the daylight colour of an article. But where colour is of little consequence, or white light is not so effective as a light rich in red or yellow rays, the Gem lamp can be used to great advantage. An article should be displayed under a light which is, as nearly as possible, of the same colour as that under which it will be used. For instance, a rug which is intended for use in an apartment where incandescent lighting is used should be selected under incandescent light.

In lighting large stores or halls, a combination of arc and Gem lamps gives very good results, and is probably the most efficient method. Where the ceilings have a height of less than 10 feet, in rooms too small for an arc lamp, in show-windows, offices, stores with hangings, porches, etc., the Gem lamp, with its proper shade, will be found entirely feasible.

In conclusion, the writer wishes to say that all lighting companies should consider the Gem lamp as being the best lamp obtainable at the present time in sizes of 250 watts or less. It may at first be put out as a specialty until it has proved its feasibility to the customer, and then be adopted as standard. The writer can see no reason why the 50-watt, 20-candle-power size should not be used to displace all carbon filament 16-candle-power lamps.

For lighting companies whose regulation will not permit the use of the 3.1-watt carbon filament lamp, the Gem lamp can be used at either its middle or bottom voltage and still give an efficiency of 2.65 or 2.8 watts per candle.

The tantalum lamp appears to the writer as not yet being in a commercial form. The first cost is exceedingly high, being about 60 cents, which is naturally a great drawback to its use, especially by central stations which furnish free renewals. Further, the tantalum lamp should be used only on direct current. The filament is extremely long, and is only gotten into a globe of ordinary dimensions by being strung in a zigzag form on a hub of projecting hooks. On account of this form of suspension, the lamp can be burned only in a vertical position on account of the danger of rupturing the filament.

The remarkable high efficiency of the lamp is, of course, due to ability of the metal to withstand a higher temperature than any carbon filament. The writer recently tested one of the tantalum lamps manufactured by the General Electric Company, and found the mean horizontal candle-power to be 25, with a consumption of 47 watts, giving an efficiency of 1.8 watts per mean horizontal candle-power. The end-on candle-power, however, is very low, being only about 5. This, however, is not a serious disadvantage, since a properly designed shade will give a sufficiently even distribution of light under the lamp.

The life of the lamp is claimed by the maker to be 750 hours, but no information is at hand showing if this claim is substantiated in commercial use.

The Moutiers-Lyons High-Tension Direct-Current Transmission

THE new high-tension direct-current transmission system from Moutiers to Lyons, a distance of 288 miles, is described in a recent issue of "The Electrical Review," of London. The maximum pressure is 60,000 volts. The district lying to the east of Lyons contains many water-power stations, and the new power supply consists of an interesting combination of three-phase alternating current and high-tension direct current.

The generating station at Moutiers transmits energy 214 miles to a switch house at Sablonnières, which also forms the center of a converging three-phase system of transmission lines bringing energy from Bellegarde (10,000 H. P.), Avignonet (8000 H. P.), Lechylienne (8000 H. P.), and La Bourne (5000 H. P.) The arrangement of these lines is shown in Fig. 1. The whole system is under the control of the Société Grenobloise de Force et Lumière. All these plants supply 50-cycle, three-phase energy at 26,000 volts, with delta-connected transformers at the receiving end.

From Sablonnières, the total energy is transmitted 64 miles to Vaulx-en-Velin by two sets of three-phase lines and two direct-current lines, the total power required for Lyons being then transmitted 7 miles to a receiving station. Here the energy is converted by three-unit motor-generator sets to direct current at 600 volts for the traction system.

In the Moutiers station, four Thury groups are provided, each driven by a separate turbine. Each group consists of four armatures and four field frames in two pairs, each mounted on a common cast-iron base and separated from the other pair by an insulated friction coupling, the whole being then coupled to the turbine through another similar coupling. The bases of the machines are held by bolts which fit into the inside of double-cup insulators embedded in an insulated foundation.

Each group has one ammeter, one voltmeter, a switch, and a pair of horn lightning arresters with resistance, arranged in the manner shown in the general scheme in Fig. 2.

The object of arranging the generators in this way is to overcome the objection raised previously, with regard to the difficulty of increasing the capacity of a Thury system without raising the pressure, and thus making it necessary to purchase a

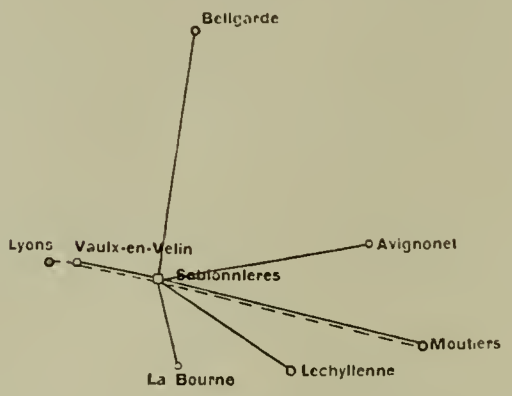


FIG. 1.—DIAGRAM SHOWING RELATIVE LENGTH AND LOCATION OF HIGH-TENSION LINES SUPPLYING HYDRO-ELECTRIC POWER TO LYONS, IN FRANCE

completely new equipment of line insulators, since the two units on one bedplate and the same shaft may be placed in parallel, thus doubling the current on the line, and the additional apparatus to be purchased placed in series, for giving the necessary increased capacity.

Each group in the Moutiers station has a maximum pressure of approximately 15,000 volts (3300 per commutator), and the line current is 75 amperes, thus giving a total output from the station of approximately 4500 KW.

Provision is made for grounding the center point of the system, and also either line, in case of breakdown. On leaving the station, the line passes to the first earthing station at Chignin, where the section between Chignin and Moutiers, or Chignin and the second earthing station at Sablonnières, may be grounded.

The Sablonnières cabin is situated approximately 64 miles from the Vaulx-en-Velin station, and contains in addition some switching gear for disconnecting, in case of necessity, the three-phase lines which converge at that point. The idea is to operate this system with the center point earthed and the two lines insulated, so that in case of accident, or if it is necessary to replace the insulators, etc., on either the positive or negative, that line may be grounded, and the earth used for transmission.

The equipment at both the earthing stations for the direct-current system contains four ammeters; this enables observations to be taken of the current passing either into or out of the cabin, and by the earth or by the wire. The earth connections at these cabins simply consist of iron plates, scattered over a small area, and buried wherever possible in wet earth.

M. Thury claims that a drop of not more than a maximum of 200 volts exists between the ground and the line when carrying the full current of 75 amperes.

At the Vaulx-en-Velin station, three groups are provided, each consisting of two Thury machines connected by an insulated flexible coupling to a three-phase alternating-current machine, the former being mounted on a common bedplate insulated from the earth. Each set has a capacity of 800 H. P., with a maximum pressure of about 7800 volts across each direct-current group. The alternating-current machines are wound for 11,000 volts, 50 cycles.

The greater part of the alternating current is stepped down for use in factories, which are thickly scattered over the district, this being the reason for using both three-phase alternating current and direct-current transmission lines between Sablonnières and Vaulx-en-Velin, since the direct current offers advantages in transmission, but does not at present offer such facilities as a three-phase line for factory supply.

The function of the Vaulx-en-Velin station is somewhat complicated. It forms a final receiving point for all the power transmitted toward Lyons, and acts also as a reserve station, so that in case of breakdown at Moutiers, or on the transmission line from Moutiers, the alternating-current machines at Vaulx-en-Velin may be driven as synchronous motors, operating the Thury machines as generators to supply Lyons; and in case additional three-phase energy is needed, the Thury machines may also be operated as motors, driving the alternating-current machines as generators.

The Vaulx-en-Velin station also contains two special 600-volt 47-ampere shunt-wound generators, each driven by an induction motor mounted on the same bedplate, all these machines being used as exciters for the three-phase machines, and also to start the Thury machines as motors, in case of a breakdown at Moutiers occurring while none of the machines in Vaulx-en-Velin are operating.

From Vaulx-en-Velin energy is supplied to Lyons through underground cables to the receiving station at the Rue d'Alsace, where it will be transformed for transmission purposes by five groups, four of which are installed.

In all the stations of this system,

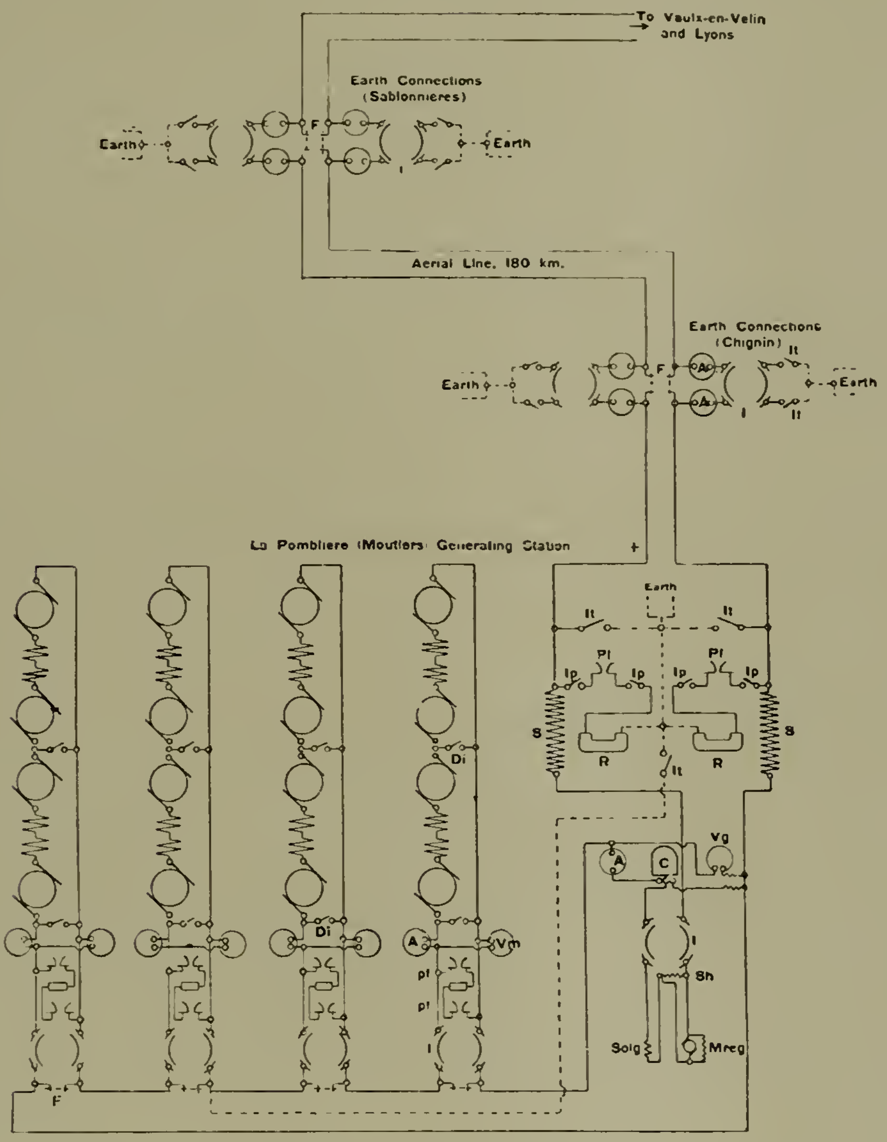


FIG. 2.—GENERAL ARRANGEMENT OF THE THURY HIGH-TENSION DIRECT-CURRENT EQUIPMENT IN THE MOUTIERS STATION

M. Thury employs his old method of insulating all the machinery in the station from the earth by means of an insulated flooring, which consists of an upper layer of pure asphalt approximately 1 cm. thick; next a layer of asphalt and small stones about 1½ cm. thick; and finally, the concrete foundation. It is stated that this flooring will withstand 80,000 volts alternating.

The machine bedplates are supported by double-cup insulators which fit into a foundation about 6 inches above the surface of the flooring, the space between the two insulators and the space surrounding the bolt being filled up with litharge.

The Pennsylvania Railroad has inaugurated electric service on the first of its electrified lines by substituting electric for steam service on the Somers Point branch of the West Jersey & Seashore Railroad. Trains at present are electrically operated between Pleasantville and Somers Point; but additional lines of the Camden-Atlantic City road will be ready for the new motive power within a short time.

Soft Graphite Made Electrically

EDWARD G. ACHESON, of Niagara Falls, N. Y., has announced that he has discovered a process for making unctuous or soft graphite. Heretofore the graphite made by the International Acheson Company has been hard graphite, and has been applied to a field not entered by the natural graphites, such as in the manufacture of electrodes, as a battery filler, and as a paint pigment. The soft graphite will be used as a lubricant, as a stove polish, and also for coating gunpowder, which is tumbled in graphite to coat or face it. It will also be used for electrotyping.

As it can be manufactured at comparatively low cost, it is expected that the new, soft graphite will become a successful competitor of natural graphite. The product of the experimental furnaces has been very satisfactory as to uniformity. Mr. Acheson predicts that within a few years the manufacture of artificial graphite will be the largest industry at Niagara Falls.

Wireless Telegraphy for Trains in Bavaria

THE ministry of Bavarian state railways has decided to install the Marconi wireless telegraph system on some of its trains to transmit signals and orders. The system will be tried experimentally on a single track line.

There have been extensive experiments of short-distance wireless telegraphy made by the General Electricity Company, of Berlin, on some Bavarian roads near Munich, and they are said to have been successful. While the minister for railways was on one of the trains a message was transmitted to him from Berlin, 200 miles away. The receiver was fitted on the train's locomotive.

The apparatus to be installed will permit not only the receipt of messages while the train is in motion, but also the sending of dispatches. The engineer is notified that a message is to be sent by a bell signal and a few seconds later the signs appear on a paper band.

According to the annual report of the Railroad Commissioners of Connecticut, the electric roads carried over 50 per cent. more passengers during the year ending Dec. 31, 1905, than the steam lines. The steam roads carried 64,403,149 passengers and the trolley lines 102,849,160.

Advertising and New Business Getting

By C. A. PARKER

From a Paper Read at the Recent Convention of the Ohio Electric Light Association

THERE has been so much said and written to and for and at the central station men in the past few months in regard to new business getting and advertising that it is not astonishing that some central station men are a little inclined to resent what may appear to them to be an unwarrantable intrusion on their affairs by a lot of meddlers and outsiders.

We heard of one central station man who wanted to know "what all this fuss was about, anyway, and did anyone think they could come along and tell him how to run his business? If so, they were grandly mistaken."

Now, that's a wrong and a narrow-minded way to look at it. If you were to go to a merchant and try to show him that an electric sign would bring him good returns, would he be justified in telling you that he wouldn't stand for your coming around and showing him how to run his business? I think not.

Would the factory man be wise in resenting your efforts to interest him in individual motor equipment as an intrusion upon his affairs? Assuredly he wouldn't. If such an attitude were universally adopted business would go out of business. These things are matters of business, —they are business propositions.

So, too, when the technical press, advertising companies, and affiliations of jobbers and manufacturers approach the central station man with advice and argument in favour of a broad and enterprising commercial policy, it is not in the spirit of pedantic arrogance, but in the spirit of business "hustle."

So I say we are not meddlers. We are not intruders. We are business men "out for business." We believe electricity is tremendously under-advertised; we know it is; you know it is.

We know that modern, aggressive business methods would be exceedingly profitable to the central station adopting them and to the electrical art and industry as a whole.

And, what is still more important, we believe that now is the time to "get busy." The hour is ripe. The country is prosperous. People are intensely interested in electricity. They await the word from you. Will you turn a deaf ear?

It is no reflection upon the central station man that he has been a little conservative in his commercial policies and activities in the past. Quite the contrary.

Electrical science has only just reached the stage where active commercialism would be desirable or even possible. It has evolved through many quick-sands and conditions where an active commercial policy would have been suicidal.

The "flat-rate" error had to be fought out and eliminated before the central station could even afford to whisper in an advertising way. Machinery had to be standardized. Lessons had to be learnt in regard to the maintenance and protection of transmission lines, etc.

The successful central station man of the future is going to be the good all-round business man who believes in running his central station at least as aggressively as if it were a dry goods store or a tailor shop.

Why, even the peanut man displays his goods and has his rotary converter that makes a noise like "roasting peanuts,"—he does something to "make you want 'em."

Why should the central station man, purveyor of one of the most advertisable things in the world, shut himself, as he too often does, in a gloomy barracks of a power house way out on the city limits, and preserve a deadly silence towards the rest of humanity?

The successful central station of to-day and to-morrow are those where a possible customer is welcomed and made much of; where bright, well-trained solicitors are kept constantly busy calling on interested people; where good, live advertising, capable of arousing popular interest, is sent out to lists of residences, stores and factories situated on, or adjacent to, the company's lines and mains; and where, throughout the entire institution, there is a broad-minded, up-to-date business welcome for new business and a proper fostering care of the business already contracted for.

I think,—and actual experience in preparing advertising for a number of central stations in all parts of the country bears me out in this,—I think no kind of advertising can be so powerful an agent in securing new business as a well-conducted, well-edited monthly bulletin, sent by mail to lists of people on the company's mains and lines.

Such a bulletin takes precedence even over newspaper advertising, in which much circulation is necessarily lost by appealing to people not on the lines or mains of the company.

The monthly bulletin can treat entertainingly of so many different uses of electricity, can illustrate, can instruct, can drive home the point. It comes to be looked for each month, and becomes a strong factor in securing and retaining the public good-will and friendship.

One of the strongest values of such direct-by-mail advertising is that it paves the way for the solicitor, it secures inquiries, and it allows the solicitor's calls to be concentrated principally on the interested parties in the community.

The solicitor, whose coming has been heralded by good, forceful, direct-by-mail advertising, finds a ready acquaintance with electricity, the a b c's have been learned, the missionary work has been done; he finds, too, that the desire has been created to a considerable degree.

As a result, but little of his energy will need to be devoted to making the prospect want electricity. Consequently, he can use nearly all his effort in the closing of the contract and the formation of the most mutually profitable deal for his customer and his company.

Just one last word—I thing every central station man, of all men in the world, ought to believe in advertising. And, of course, if he does believe in it he ought to use it.

You should believe in it because you are in the advertising business yourselves. You are selling electric light to the merchant for his window display, and you tell him that that light is the best advertising he could use, do you not? And you are right.

You do the same with electric signs, do you not? And you are right, again! everlastingly right!

You are in the advertising business, every man of you, and if you show a lack of faith in advertising, if you fail to have your own electric sign, or signs, if you assume a narrow, unaggressive, unadvertising attitude towards the public, are not your pretentions as a seller of electricity for advertising purposes going to suffer?

You are, yourselves, in the advertising business. Will not a hearty faith in advertising and a good, live, aggressive use of it in its most efficacious forms be a wise and desirable acquisition to your personality as a successful central station business man and to your company as a revenue-strengthener and as a fostering influencer of the good-will of the public.

Electrical and Mechanical Progress

Motor Drive in a Lumber Mill

In many respects the conditions encountered in lumber mills present problems in power transmission that are not found in other industries. The inflammable nature of the material used, the size of the work handled and the severe power demands for starting and operating wood-working machinery of necessity require a motive power that is not only immune from fire risk but one that will withstand heavy fluctuations in load and operate the various machines with as little obstruction to the handling of material as possible.

The foregoing conditions led to a demand for some method of operation that would in the main eliminate many of the objectionable features, and electric drive was the natural outcome. By its adoption the various floors and section can be subdivided so that any machine or group of machines may be operated independently, producing a flexibility which is especially valuable in overtime work, when power requirements are small.

A 15-H. P. WESTINGHOUSE INDUCTION MOTOR DRIVING A PLANER IN THE LUMBER MILL OF THE EGGERS & GRAHAM LUMBER COMPANY, UNIONTOWN, PA.

It was these considerations that led the Eggers & Graham Lumber Company, of Uniontown, Pa., to adopt electric drive in their mills, and the installation furnishes an excellent example of this mode of operation.

The electrical equipment consists of Westinghouse two-phase induction motors operating on 60-cycle, 200-volt circuits, the current being furnished by the West Penn Railways Company. Each machine throughout the entire plant is individually driven, as shown by the following list of motors and the machines they drive:—

One ½-H.P. motor driving an emery wheel; one ½-H.P. motor driving a grindstone; one 5-H.P. motor operating a rip saw, the sizes varying from 8 to 14 inches in diameter; one 15-H.P. motor driving a moulding machine; one 15-H.P. motor operating a universal planer; one 5-H.P. motor driving a 10-inch cross-cut saw; one 2-H.P. motor operating a tennoning machine; one 5-H.P. motor driving a pony planer; one 4-H.P. motor driving a panel raiser; one 1-H.P. motor driving a shaper; one 3-H.P. motor driving a hand-feed planer; one 3-H.P. motor driving a band saw; one 3-H. P. motor driving a rip saw.

The accompanying illustrations show several of these applications and are striking examples of the severe conditions encountered in this class of service. Owing to the rush of work in this plant, the mill running night and day, there is necessarily a large accumulation of shav-

A MOULDING MACHINE DRIVEN BY A 15-H. P. WESTINGHOUSE INDUCTION MOTOR IN THE EGGERS & GRAHAM LUMBER MILL

A 2-H. P. WESTINGHOUSE INDUCTION MOTOR DRIVING A TENONING MACHINE

ings and sawdust, which, in some instances, nearly covers the motors, furnishing a forcible illustration of the immunity from fire risk secured with induction motors. Some of the motors have covers which, with the accumulation of refuse coming from machines, prohibits ventilation, and that, together with the severe starting conditions, require motors of exceptional strength, capable of operating under adverse conditions.

The installation is operating night and day and is giving entire satisfaction to the owners, who consider electric drive the only successful method of operating lumber mills.

A New Company to Manufacture Incandescent Lamps

FINANCIAL interests comparatively new to the electrical industry are now behind a new company, the Novelty Incandescent Lamp Company, which is being organized in St. Marys, Elk County, Pa., for the manufacture of incandescent lamps. This new company is being operated on an entirely independent basis, it is announced, and no understanding nor agreement as to methods or prices will be entered into with any existing association of manufacturers in this field. It is believed that the character of the men committed to the company and the policies as to sales methods and prices which it is the purpose of the management to inaugurate will be sufficient to gain the interest and sympathy of lamp buyers.

The product to be marketed will embrace the new "Elk Standard" incandescent lamps, "Novelty" miniature lamps, and "Novelty" renewed lamps. For the manufacture of the new types of standard incandescent and miniature lamps this company is now erecting a new building at Emporium, Pa., twenty-one miles from St. Marys. For handling the department devoted to renewed lamps, a two-story brick addition to the plant now occupied at St. Marys is in course of construction.

The officers of the company are R. K. Mickey, president and general manager, of St. Marys, Pa.; Josiah Howard, vice-president, of Emporium, Pa.; Joseph Kaye, secretary, of Emporium, Pa.; A. F. Vogt, treasurer, of Emporium, Pa. These gentlemen, together with Henry Auchu, of Emporium, Pa., constitute the principal members of the board of directors.

Reference to the following banking institutions will establish the financial responsibility of the concern: First National Bank, Emporium, Pa., and the Farmers and Merchants' Bank, St. Marys, Pa.

It is announced that in the near future the two plants of the Novelty Incandescent Lamp Company will have developed facilities for the production of 10,000 lamps daily.

Electric Horns for Automobiles

A NOVEL accompaniment to an automobile is the electric horn manufactured by the Vesta Accumulator Company, of Chicago, Ill.

The sound is produced by a vibrating diaphragm as in the case of telephones, the diaphragm being vibrated by means of an electromagnet. Two wires from a small storage battery join the electromagnet windings with a vibrator which serves to make and break the circuit. The vibrations of the vibrator cause a small rod surrounded by a coiled spring to strike against the diaphragm and thus produces the noise. The spring pulls the striking rod back as soon as the circuit is broken at each vibration.

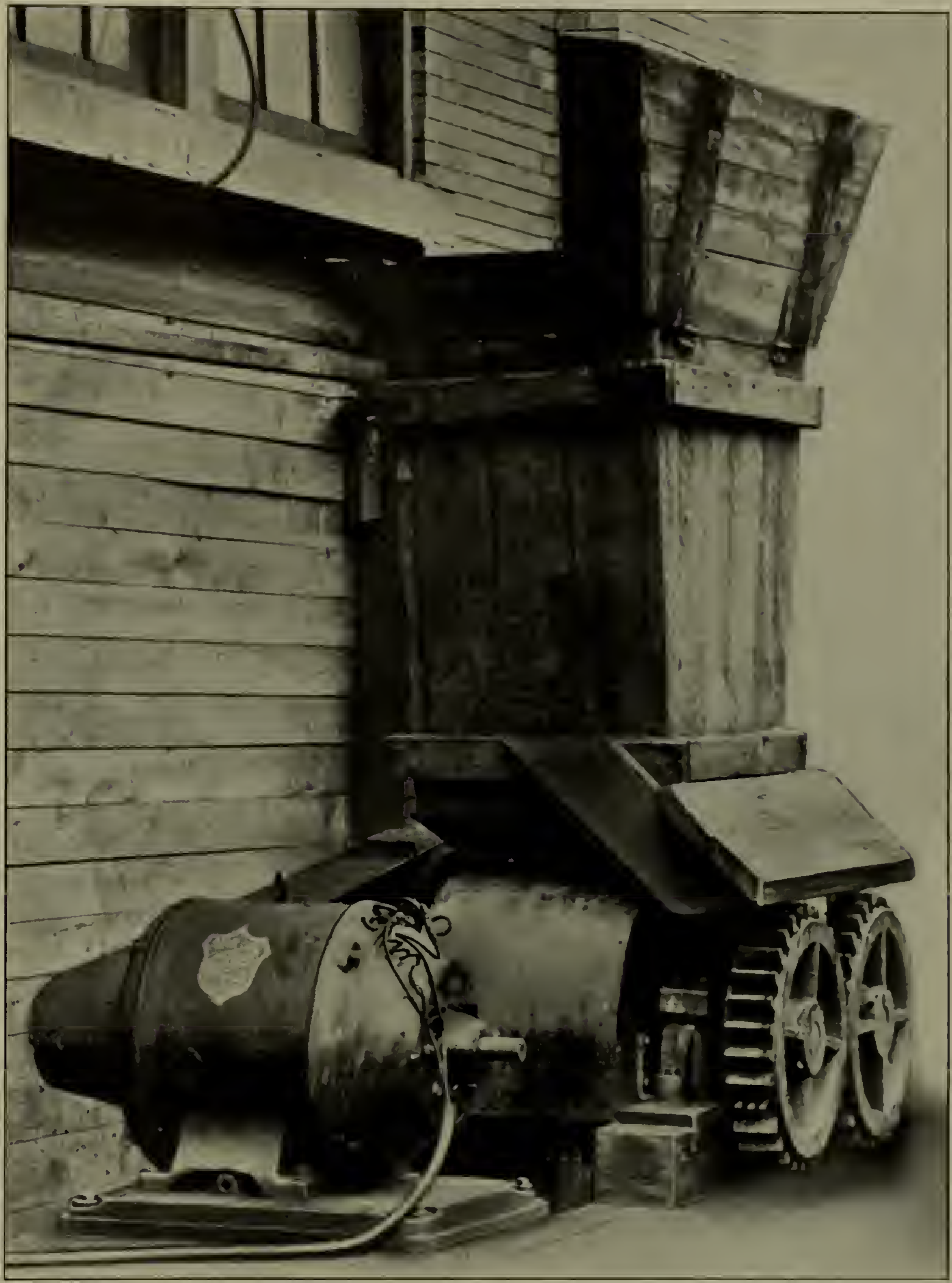
The horn is mounted in any convenient place on the car, and the battery is carried beneath the seat. The wires from the battery to the horn pass up the center of the steering wheel post, and on the rim of the wheel is a switch which can be operated by the finger without taking the hand off the wheel. The sound produced differs slightly from that of the bulb horn, yet the blast has a decidedly musical tone.

Motor Drive for Coal-Crushing Rolls

THE accompanying illustration shows a set of 24 by 30-inch coal-crushing rolls, belted to an electric motor. These outfits are built by the Allis-Chalmers Company, of Milwaukee, and are now being installed by many users of steam-driven power machinery.

In connection with furnaces at which automatic stokers are used, or where, for other reasons, it is desirable to have the coal crushed to a uniform size, the advantages of such an arrangement will be readily apparent. The coal, as it is unloaded from the car, is passed through these rolls and drops to the hopper which feeds the stokers. Where it is possible to secure coal in hopper cars at all times, a further improvement is made by placing the crushing rolls beneath the track, allowing the coal to drop from the car into the rolls, and falling from there to the stoker supply hopper.

Motor drive is the most satisfactory for an equipment of this character, as such rolls are in operation for a limited time only each day; there is therefore no waste of power and no idle belts or extra shafting to be cared for while the rolls are not in operation.



A MOTOR-DRIVEN COAL CRUSHER BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS.

The Allis-Chalmers Company is now manufacturing a full line of these rolls, which are used not only for crushing coal, but also rock salt, phosphate rock and other similar materials that do not require the heavy machinery furnished by this company for mining work and the crushing of harder materials. The company also builds the motors by which the rolls are driven.

Electricity for Light, Heat and Power in London

A SCHEME for supplying electric current to London for light, heat and power is outlined in a report recently made to the Bureau of Manufactures of the Department of Commerce and Labour. The scheme is fathered by Arnold Lupton, a member of the British Parliament.

His plan contemplates the use of electricity for power, lighting, heating and cooking in London, and bringing the electrical energy from the coal fields of the Midlands, thus doing away with the smoke-producers of the metropolis. He estimates that the smoke nuisance damages London every year fully $10,000,000, not to mention the incalculable personal discomfort it causes.

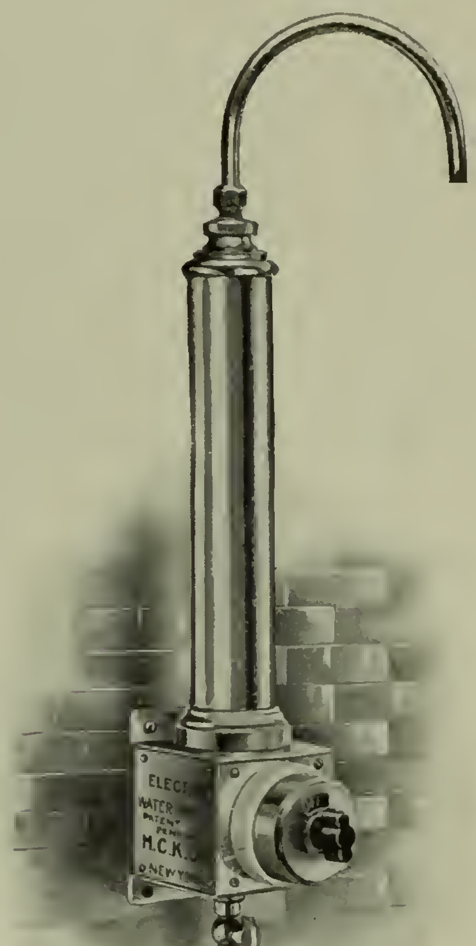
Mr. Lupon is thus quoted:—

"What I propose is to use a high-tension current of 60,000 volts and to bring the electric energy from the Midland coal fields, 120 miles away. If London were supplied with electric generators of, say, 1,000,000 kilowatts average load, the greater part of the railways, tramways and factories could get their electric lighting and power and the bulk of the houses be warmed and cooking done by electric energy. The current could be delivered in London in bulk at 1 farthing (half a cent) per unit, and therefore it could be sold at 1 penny (2 cents) and even less for large quantities.

"It is proposed to construct a plant as a beginning, to be enlarged when needed, to cost about $17,000,000. The railways may oppose this project, for it would mean a heavy annual loss to them in freight receipts for carrying coal to London. But manifestly the Midland coal fields would offer it every encouragement."

An Instantaneous Electric Water Heater

THE instantaneous electric water heater, manufactured by the H. C. K. Company, of New York, and illustrated herewith, consists, in the main, of a supporting



AN INSTANTANEOUS ELECTRIC WATER HEATER MANUFACTURED BY THE H. C. K. COMPANY, OF NEW YORK

box, upon which is mounted a double-pole, quick break switch, an insulating joint of special design to the lower end of which is attached a ¼-inch water valve. Screwed into the upper part of the insulating joint is a bronze fitting, within which is placed the cut-out which automatically opens and closes the electric circuit as the water is turned off and on.

In the upper end of the bronze fitting there is held (in a similar manner as is a water glass for a boiler) a porcelain tube, with one terminal at each end. Within the porcelain tube is placed the heating element, which consists of a specially designed spiral, made of a material which is guaranteed not to rust or corrode, or be injured in any way by the action of the current and the presence of the water.

At the upper end of the porcelain tube there is another bronze fitting, with an insulating joint above it which supports the spout. One wire leads from the switch to the upper bronze fitting on the porcelain tube, and the wire from the other side of the switch leads to the lower bronze fitting. The porcelain tube and the bronze fittings are surrounded by a brass tube, 1¾ inches in diameter. The total height of the heater from the bottom of the inlet valve to the top of the spout is 20 inches, and all fittings are nickel-plated and highly polished. The device is ornamental, and can be placed anywhere where an electric circuit can be installed.

The heater can also be furnished in combination with a water tank, to be placed slightly above it, in which case it is not necessary to connect the heater with the water system, only connecting it to the electric wiring by means of an attachment plug and flexible cable of the proper kind. Under this condition, the water heater is portable, and can be installed in any hotel room, where it can be attached to the ordinary wash-stand.

If the water valve is open, but the switch not turned on, cold water will flow from the heater. The moment the current is turned on the water becomes heated instantly, and by regulating the flow of the water the temperature can be adjusted up to 200 degrees F.

The standard heater requires about 10 amperes at 110 volts, and will heat a glass full of water to 190 degrees F. in 40 seconds, which, at the rate of 10 cents per kilowatt-hour, would cost 0.014 cent. The same heater will heat one gallon of water to the same temperature in 10 minutes for less than 2 cents. For an ordinary wash-stand, there would be required about one quart of water at about 105 degrees F. The heater would require 40 seconds to heat this water, and the cost would be less than 0.014 cent.

The absence of all odours, and the promptness with which the apparatus performs the work, should commend it for use in many places, some of which may be referred to as follows:—

For hot drinks at soda fountains and cafés.

Hot water for barber shops, manicuring establishments, etc.

In hopitals, doctors' and dentists' offices for an instant supply of hot water for general use and for sterilizing instruments.

Hotels can use this instantaneous electric water heater in many of the rooms for supplying hot drinking water, and in rooms where there is no running water, the heater can be installed in combination with the water tank mounted above it.

The heaters will be ready for delivery by October 15, and the cost of the heater complete, ready for connection to the wires and the water supply, as illustrated, will be about $15 to the consumer.

A Portable Testing Set for Naval Use

THE portable testing set, illustrated herewith, is a type recently put on the market by Queen & Co., of Philadelphia, to meet the revised Navy Department portable testing set specifications, which have been altered considerably and made much more exacting than heretofore.

The arrangement of this set has formerly been made with not only these specifications in mind, but also with a view to securing the maximum portability with due regard to convenience in mechanical arrangement, while the connections of circuits are such that a large variety of tests beyond those indicated in the Government specifications may be executed. It therefore forms an ideal set for the use of telephone and telegraph companies, electric light and power stations, and for electrical engineers who find it necessary to make a wide variety of measurements and prefer one complete testing instrument to a large number of individual pieces.

It consists in general of a Wheatstone bridge, with a 1, 10, 100 and 1,000-ohm coil in each arm. The rheostat consists of 10 coils of units, tens, hundreds and thousands denominations, the last or tenth coil being added for convenience in checking up the next higher series of coils; that is, the ten coils in the unit row in series can be checked with the first coil in the ten row and likewise the ten 10-ohm coils can be checked against the first 100-ohm coil, etc., an operation which confirms the accuracy of adjustment, but one not possible in a "Decade" set where each row consists of but nine coils and Varley loop can be employed. The resistance coils in the bridge arms are adjusted to an accuracy of 1/20 per cent., while that of the rheostat coils is 1/10 per cent., the

A NEW PORTABLE NAVY DEPARTMENT TESTING SET, MANUFACTURED BY QUEEN & COMPANY, OF PHILADELPHIA

The bridge and rheostat are properly connected to an improved D'Arsonval dead-beat galvanometer, of such high sensibility that a change of 1/10 of 1 per cent. in the rheostat when measuring resistance of approximately 1000 ohms value will give a decided galvanometer deflection. The needle is perfectly free from outside magnetic influences and so balanced that the test set can be used in practically any position; it is also provided with an adjustment lever so that the pointer of the galvanometer can also be made to indicate zero.

The battery consists of six chloride of silver cells connected so that any one or number up to six in series may be used, while a pair of binding posts allows the use of an outside battery when desired. Both the galvanometer and battery keys are on the front of the case in a most convenient location, and are made extra heavy with a liberal supply of platinum-iridium at the actual contact points. Binding posts and a small switch allow the use of an outside galvanometer if desired.

A ground post, as well as an auxiliary galvanometer switch, is provided so that both the Murray wire used being manganin with a neglıgible temperature coefficient; all the spools are well shellacked, properly baked and aged before standardizing. To the hard rubber plate, which is highly polished, and of exceptionally good quality, are securely fastened the resistance coils, galvanometers, battery, etc., so that by removing this plate all interior parts are out at the same time.

The individual cells of battery can be removed by unscrewing a small section of the bottom of the case, which exposes them to view, when the connections can be loosened and new cells inserted when necessary.

The over-all dimensions of the set are approximately 12 by 8 by 6 inches, and the weight is about 12 lbs., the cases being made of polished quartered oak, and protected with nickel-plated brass corner pieces.

In addition to the usual measurements of resistance, this set can be used for locating grounds, crosses and other cable troubles using either the Murray or Varley loop tests, while it can be used for insulation resistance measurements and numerous other tests, such as checking up voltmeters and ammeters, measuring battery resistance, etc.

Personal

J. F. Davis, formerly connected with the Pittsburg organization of the Atlas Engine Works, Indianapolis, has been transferred to the company's offices at Chicago.

G. Percy Cole, assistant chief engineer of the Wagner Electric Manufacturing Company, of St. Louis, Mo., has resigned to accept a similar position with the Allis-Chalmers-Bullock Company, of Montreal.

J. Lester Woodbridge, formerly engineer of the sales department of the Electric Storage Battery Company, Philadelphia, has been appointed chief engineer of that company, succeeding J. B. Entz, who has resigned to accept the position of vice-president of the Electric Vehicle Company, of Hartford, Conn.

J. P. Johnston, for several years past the general sales manager for the Weber Steel Concrete Chimney Company, of Chicago, has resigned to become sales manager of the water-tube boiler department of the Atlas Engine Works, of Indianapolis. Mr. Johnston's offices will be at the company's plant in Indianapolis.

William Marconi has been retained by the Columbia Phonograph Company as a member of its experimental staff. In a recent trip abroad, Edward D. Easton, president of the company, secured Mr. Marconi's services in furthering the development in the art of sound recording and reproduction.

J. M. Broucher, of the Brownell Company, of Dayton, Ohio, has resigned his connection with that company to accept the position of assistant general manager of sales for the Atlas Engine Works, of Indianapolis.

Baxter Reynolds, formerly of the Nernst Lamp Company, is now in charge of the electrical department of Fairbanks, Morse & Co., in the East, with headquarters at 12 Dey street, New York City.

N. F. Brady, vice-president and treasurer of the New York Edison Company, was married on Aug. 11 at St. Joseph's Cathedral, Hartford, Conn., to Miss Genevieve Garvan, daughter of Mr. and Mrs. Patrick Garvan, and sister of Assistant District Attorney Garvan, of New York City. Mr. and Mrs. Brady have sailed for Europe for a tour of three or four months.

George Howe, formerly general manager of the Metropolitan Engineering Company, of New York, has opened an office at 150 Nassau street, in the same city, as consulting electrical engineer and contractor. Mr. Howe has had a wide range of experience as engineer and executive in charge of engineering work, and has successively occupied positions as assistant professor of physics at Tulane University, engineer of the the United States Engineering Corps at New Orleans, in the testing department of the General Electric Company at Schenectady, sales engineer of the Fairbanks Company, power expert of the New York Edison Company, and latterly general manager of the Metropolitan Engineering Company. He is prepared to submit plans, specifications and estimates for electrical work of every description, to operate power plants, to place poorly-paying properties on a profitable working basis, to organize business-getting campaigns, to audit electric lighting accounts, and to act as the purchasing agent and general New York representative for out-of-town electric plants. Mr. Howe's many friends will be interested to know that he has already closed a number of profitable contracts.

GEORGE HOWE

Max Lowenthal, the well-known consulting electrical heating engineer, having been commissioned by John Wanamaker to reorganize his electrical supply department, is now installing a very elaborate display covering a floor area of 1600 square feet, in the basement of the new New York building. A model kitchen and bedroom are being erected, in which every conceivable electro-domestic appliance, from a push-button to a refrigerating plant, will be shown in actual operation. Electric cooking will be demonstrated at another portion of the exhibit, which will be open to the public during the first week in September.

Howard E. Troutman, for over ten years connected with the Buckeye Engine Company, and for several years manager of its Chicago office, has resigned to accept the sales management of the Corliss and high-speed engine department of the Atlas Engine Works, of Indianapolis. Mr. Troutman's headquarters will be at the home office.

George B. Tripp, formerly general manager of the Colorado Springs Electric Company, has become associated with Curtis & Hine, engineers and central station managers, with headquarters at Colorado Springs, Col. Mr. Tripp had been connected with the gas and electric interests at Colorado Springs for five years, and under his direction these properties have been very successful. He is one of the best-known men in the Western field, and for several years has been secretary-treasurer of the Colorado Electric Light, Power & Railway Association.

W. H. Whiteside, president of the Allis-Chalmers Company, of Milwaukee, returned on August 22 from a two months' combined business and pleasure tour of England, France, Germany and Switzerland. Mr. Whiteside inspected various large manufacturing industries of England and on the Continent, including the leading English steam turbine builders, whose American rights for building Parsons steam turbines for marine and land use are held by the Allis-Chalmers Company.

Obituary

James Dredge, one of the editors and proprietors of "Engineering," of London, is dead. He had been in ill health for some time. Mr. Dredge was well known in engineering circles of America and was a Royal Commissioner to our Centennial and Chicago exhibitions. With Mr. Maw he built up "Engineering" into a great journal and its pages have always been pervaded by a spirit of fairness and good fellowship for all the world. Willingness to accept and advise the acceptance of new ideas, freedom in pointing out directions in which improvements might be made in the practice of his own countrymen and a general broadmindeness have characterized the journal, which, though not due solely to Mr. Dredge, could not have obtained to such an extent had he not been in hearty sympathy with such ideas, as in fact he was known to be.

E. T. Hannan, the inventor of the "Atlas" water tube boiler, died at Chicago, on Saturday, August 18, just as he was entering a train with J. P. Johnson, of the Atlas Engine Works, to go to the latter's home at Evanston. His death was due to heart disease. In the three years that Mr. Hannan had been with the Atlas company he has grown steadily in their esteem and had only recently been promoted to assistant manager of sales of the Water Tube Boiler Department, his exceptional ability as a salesman warranting his being changed from the Philadelphia office and placed in the broader field. He was just entering upon his new duties when he was stricken down. His death is considered a distinct loss to the company.

Trade News

W. S. Barstow & Co., of New York, have recently completed an extensive electrolytic survey for the Chester Traction Company, Chester, Pa., and the Trenton Street Railway Company, of Trenton, N. J. Under their direction, several modifications have been made which bring the track return systems of these two companies up to date.

The following are some recent sales of the new design of side-crank automatic engines, built by the Ball Engine Company, of Erie, Pa.:—

One 100-H. P. and two 200-H. P., Commonwealth Trust Company, Pittsburg, Pa. One 200-H. P., Chicago Varnish Company, Chicago, Ill. One 256-H. P. and one 100-H. P., Holdredge Lighting Company, Holdredge, Neb. One 335-H. P., Philadelphia Post Office building, Philadelphia, Pa. One 100-H. P., Deepwater Railway Company, Deepwater, Va. One 320-H. P., Henderson Light & Power Company, Henderson, N. C. One 210-H. P., T. A. Gillespie & Co., Pittsburg, Pa. Two 320-H. P., United Hebrew Charities, Chicago, Ill. One 150-H. P., Germain-Boyd Lumber Company, Atlanta, Ga. One 100-H. P., Washington Gas & Electric Company, Washington C. H., Ohio. One 320-H. P., Taylor Coal Company, Beaver Dam, Ky. One 210-H. P., Isthmian Canal Commission, Washington, D. C. One 150-H. P., Natalbany Lumber Company, Montpelier, La. Two 100-H. P., Jewish Hospital, Cincinnati, Ohio. Two 150-H. P., West Unity Power & Light Company, West Unity, Ohio. Two 100-H. P., Sweetbrier Institute, Amherst, Va.

The rapid expansion of the business of the Locke Insulator Manufacturing Company, of Victor, N. Y., has taxed to the utmost all the facilities of the old power plant, until, at the present time, the construction of a new and larger one has become imperative. The new building, for which foundations have already been laid, is to be 90 feet square, of approved concrete construction, one side being parallel to, and 15 feet below, the tracks of the New York Central & Hudson River Railroad, enabling hard and soft coal to be unloaded directly to the bunkers. The boiler room, which measures approximately 45 by 90 feet, will contain 600 horse-power in horizontal tubular boilers, hand-fired with a mixture of buckwheat and soft coal, necessary draught being provided by a large engine-driven fan. Engines, generators and high-tension testing transformers will occupy the remainder of the building. There will be two power units, one for day load and a smaller one for night load, the demand for power being practically continuous. The smaller unit, of 60-KW. capacity, is made up of a Skinner engine running at 300 revolutions per minute, direct connected to a three-phase, 60-cycle, 440-volt alternator. The large unit, a low-speed Corliss, will be direct connected to a three-phase, 60-cycle, 440-volt alternator of 150 KW. These two machines will supply light, power and current for testing all through the factory, as well as supply power for street and residence lighting in the village of Victor.

The Carborundum Company, of Niagara Falls, has started construction work on a large branch plant in Germany. This company is the sole American manufacturer of carborundum in the various forms in which it is used for grinding purposes, and the demands of its European trade have increased so rapidly that the establishment of a branch works on the Continent has become absolutely necessary. A Germany Company has been formed under the title, "Deutsche Carborundum Werke, G. m. b. h." The new works are located at Reisholz, a manufacturing suburb of Dusseldorf. This city is situated on the Rhine, and has unusual facilities for distribution of products, both to Germany and to other European countries. The construction of the new plant is under the supervision of one of the American engineers of the Carborundum Company. Five kilns for the manufacture of vitrified wheels are provided for, two of these to be built at once. The buildings, when completed, will embody all of the latest and most improved machinery for the manufacture of abrasive materials. It is expected the new works will be in operation by Jan. 1, 1907. The Carborundum Company has for some time maintained large stores in London and Berlin, and has agencies in most of the principal cities of Great Britain, Germany, Denmark, Norway, Sweden and Russia. With the completion of the German works, the European business can be largely increased on account of the better service that can be given.

The Atlas Engine Works, of Indianapolis, whose Chicago sales offices have for several years past been in suites 900-902 Fisher building, will, upon completion of the new Fisher building in November, increase their present rather cramped quarters by the addition of several larger offices. Frank H. Baker, connected with the Atlas Engine Works for over twenty years, will continue at the head of its Chicago organization.

New Catalogues

Telephone and annunciator practice, as exemplified in the installations of the Electric Goods Manufacturing Company, of Boston, Mass., is illustrated and described in a catalogue recently issued. The illustrations show a variety of annunciators, central energy switchboards for factory, office and hotel use, and "annunciphones," which are combined annunciators and telephone switchboards. Telephones for use on private lines are also illustrated.

A folder recently issued by the Oswego Boiler & Engine Company, of Oswego, N. Y., contains, in tabulated form, the various dimensions and particulars of stationary return tubular boilers for 100 pounds pressure.

A pamphlet recently issued by the Sargent Steam Meter Company, of Chicago, deals with the meter manufactured by the company for indicating the pounds of steam flowing through it irrespective of the pressure. The meter may also be calibrated to read directly in horsepower. The Sargent indicating angle meter, for determining angular velocity, and a draught gauge for pressure or vacuum, are also illustrated and described.

"Through 'Frisco's Furnace" is the title of a pamphlet recently sent out by the Joseph Dixon Crucible Company, of Jersey City, N. J., showing a number of buildings in San Francisco on the steel work of which Dixon's silica-graphite paint was used. The illustrations are offered as an evidence of the protective value of this paint.

A pamphlet recently sent out by the Rockwell Engineering Company, of New York, illustrates and describes high and low-pressure oil burners, a fuel oil pumping system, positive pressure blowers, and a variety of fittings for use in connection with oil-burning furnaces. A series of pamphlets deals with a double-chamber metal-melting furnace, and other furnaces for cyanide hardening and melting soft metals, for brazing, for heating rivets, for welding flues, and for annealing and hardening. In all these either gas or oil may be used as a fuel.

Metallic packing is illustrated and described in a pamphlet recently issued by the C. Lee Cook Manufacturing Company, of Louisville, Ky. The packing is made in single and double types for piston rod and valve rod use. The double type is intended for vertical engines where trouble is had from condensed steam in the cylinder working down with the rod.

A pamphlet, illustrating and describing medium speed, automatic, four-valve engines, was recently issued by the Atlas Engine Works, of Indianapolis. The several parts are shown in detail and the various engine sizes are tabulated.

Gas and electric portable lamps manufactured by the Goodwin & Kintz Company, of Winsted, Conn., are illustrated in a catalogue recently issued. It would be impossible here to describe the wide variety of lamps illustrated. Suffice it to say that the company is evidently prepared to gratify every possible variety of taste.

It is reported that to maintain telegraphic communication in case of a strike, the Russian Government has established a system of wireless telegraph stations. One is at St. Petersburg and another on the German frontier. Communication with Finland is also possible between the capital and fortress and garrison towns.

The Relation of Alternating Current Motors to Central Station Business

By E. W. LLOYD

From a Paper Read at the Recent Convention of the Association of Edison Illuminating Companies

THE bearing that the development of the alternating-current motor has on the securing of power business is greater than generally supposed.

We all run across cases where business was lost because we could not secure motors that would do the work as satisfactorily as the direct-current motor, the margin between the cost of the operation of a private plant and central station service being so small that in order to secure the best results from the machinery, the manufacturer often decides to install his own plant and direct-current motors with a resulting loss to the central station company.

If we can secure motors that will do the work asked for by the customer, we will help our own cause materially. With the increase in the capacity of central stations and the tendency towards the generation of alternating current at high potential in large units, it has become possible to furnish power in large quantities at a low price to the consumer several miles from these central stations.

If this power can be furnished directly from our overhead or underground lines with the use of transformers instead of installing substations, even for large quantities of power, the saving to the central station companies will be material.

The past few years have seen a large increase in the use of alternating-current motors in connection with factory work. This has been largely due to the decreased cost of these motors, the prices now approximating closely prices of direct-current motors of the same sizes and speeds.

Except on tools and machinery requiring variable speeds, the alternating-current motor is generally admitted to be a better prime mover than the direct-current motor, owing to its overload characteristics. This motor having been developed to a point where it can be guaranteed as a perfectly reliable prime mover as far as ordinary work is concerned, we are only waiting for the development of variable-speed work for factory use.

There have been numerous developments on single and multi-phase motors for variable-speed work by different manufacturers, one company having on the market single-phase motors up to 3 H. P. that will do variable-speed work with very fair results. While, as with the three-phase motor, the operation of this type of motor is not so successful as the direct-current motor, still it is a great step in advance and of the utmost importance to central station companies.

Already the possibility of equipping cranes and hoists with alternating-current motors has been realized. In Chicago we have several manufacturers using current from the three-phase, 220-volt, 60-cycle system who have their factory equipped with traveling cranes using three-phase motors. These equipments, while not perfect, are reliable enough so that the parties using them are very well satisfied. In fact, one large customer, having approximately 700 horse-power in motors, is changing over a number of traveling cranes from direct-current to alternating-current motors. This is being done in order to save the loss in the changing from alternating to direct current through rotary converters. One large alternating-current crane is already in operation, and is proving entirely satisfactory.

We have also equipped several jib cranes with alternating-current motors with satisfaction, being able to handle moulten metal in 5-ton ladles with perfect safety. One large foundry has several ladles running on tracks equipped with variable-speed alternating-current motors, enabling the operator to tip the ladles at will, and as easily as if equipped with direct-current motors.

For small printing press work we have arranged to install three-phase variable-speed motors on cylinder presses, and while we know it is not possible to get the wide range of speed or efficiency possible with the direct-current motor, still the installation is a vast improvement over the old installation or belt drive and cone pulley.

The possibility of equipping alternating-current motors with automatic starting devices is bound to be realized. With this device it is possible to start and stop a motor driving an air compressor from the varying pressure in the storage tank. One company has a starter ready for the market which it will guarantee.

With alternating-current motors doing the work described above, the troubles of obtaining power business in larger quantities are to some extent overcome, as one of the most difficult obstacles in the way of obtaining this business was the fact that the alternating-current motor was not capable of giving anywhere near the duty to be obtained of the direct-current motor.

The alternating-current motor has many advantages:—its ability to operate under overloads, which would destroy a direct-current motor; it can operate in dirty places without extraordinary attention; its freedom from sparking; and last, but not least, the low cost of maintenance.

The manufacturers of alternating-current apparatus have not yet made these motors to meet conditions required in individual driving, such as that used in connection with stereotype machinery, printing machinery, bookbinding machinery, or any of the small tools now generally equipped with individual motors, but there is no reason that this cannot be done. Alternating-current motors equipped with back-gears would find a ready market to-day, as the demand for individual drive on all classes of machinery in factories is more pronounced every day.

As near as the writer can ascertain, there has not been the demand on the manufacturers for variable speed in these motors that there might have been, the manufacturers being left to do the experimenting, if not leisurely, still not as fast possibly as if the demand had been greater and more urgent. Certain manufacturers of apparatus have refused, not later than a year ago, to manufacture traveling cranes equipped with alternating-current motors, and if it had not been pointed out to them in a forcible manner that their competitors would get the business, they would still be in the same frame of mind.

If our central station power business is to increase in outlying districts and we are to take care of this business with the same advantages to the customer as in the districts where we furnish direct current, we must have a prime mover that will fit all cases. In our efforts to obtain power business in the alternating-current districts, we find that it is essential that we be able to recommend to our customers elevators that will operate satisfactorily on the alternating-current system without undue disturbance to the pressure on these lines.

There has been a large amount of money and a great deal of thought put into the development of a direct-connected alternating-current electric elevator, but it is safe to say that the progress made in the last two years has been greater than in the previous ten, and that the next two years will see even greater advances along these lines.

We can now see alternating-current multiphase motors in connection with elevator service giving excellent results, as the manufacturers are ready to place on the market machines of this type that have been perfected to such a point that their operation is quite satisfactory, the manufacturers stating that the machine takes about double full-load current in starting. While, as true of other alternating-current motors for regular duty, they are not yet so good as are direct-current motors, still these elevators are very excellent indeed, considering the many difficulties that were necessary to be overcome in connection with their design and manufacture.

It is possible to-day to obtain an alternating-current direct-connected multi-phase elevator that is practically noiseless in its operation so far as the motors, brakes and controller are concerned, and as these three sources of noise have been the objectional feature in alternating-current elevators in the past, we can safely say that an elevator of this type can be secured that is practically noiseless.

The writer had the pleasure of examining a machine of this type in operation, and it was as free of noise as is necessary, running practically the same as a direct-current drum-type machine. This machine is equipped with magnet control, the main magnets operating directly from the alternating-current circuits. Driven from the worm shaft by a Renold silent chain is a small direct-current dynamo, which is used to furnish current to the acceleration magnets on the controller.

Machines of the larger sizes are equipped with this direct-current dynamo, while machines of smaller sizes for apartment-house work can be operated with alternating-current magnet controller without the use of direct current, and the elevator companies are prepared to take orders for this class of machine at this writing.

The manufacturers have had in operation in their shops for nine months an alternating-current motor with alternating-current magnet control. They claim that the machine has not had any further adjustment than that which would be required by an ordinary direct-current controller. This machine was also automatically operated by push buttons.

While this controller was not seen in operation, the writer will say that the alternating-current magnets operated in conjunction with the elevator, which was equipped with a small dynamo operating the acceleration magnets, did not make a particle of noise. The elevator in question had a speed of 210 feet a minute. The elevator company promised speeds up to 300 feet a minute for 1500-pound lifts.

These elevators are equipped with alternating-current magnet brakes in the same general way as the direct-current elevators. The brake on the worm shaft seemed to work perfectly. In addition to the electric brake, this car was equipped with a device preventing accident to the elevator should there be any phase changes on the line. This device would prevent the operation of the car until the trouble was rectified.

The push-button type of elevator has not received the support from central station companies that it should. This type of elevator is in an excellent state of development, and there is no doubt a wide field for its use in apartment buildings in outlying districts. This push-button elevator has been perfected in connection with an alternating-current multi-phase motor to such an extent that it can be operated very satisfactorily, at least good enough for all ordinary purposes.

The hoisting part of the apparatus runs very smoothly, and the controlling part of the mechanism is very fine indeed, it being practically impossible to have an accident on this type of machine through any thoughtlessness on the part of the person operating it.

Outside of New York, the writer is not aware that there are any automatic elevators to speak of, even in the largest cities in this country, while in Europe they are quite common.

Taking it altogether, the situation as regards the electric elevator is very flattering indeed. The progress being made is very good and promises to continue. The experiments being conducted in connection with all types of electric elevators cover a large field, and a great deal of money is being spent and many able men are constantly designing new devices for the perfection of this class of elevator.

The progress in the design of single-phase motors in connection with direct-connected elevators has not been as satisfactory as with the multi-phase motor. We have one single-phase, direct-connected elevator on our lines in Chicago which was installed to replace an old 500-volt machine. The old apparatus was used; the motor and controller only being changed. The operation of this elevator, while giving fairly good results to the apartment building, is hardly satisfactory to us, as the starting current is about five times the full load current. When the line is well loaded the effect is not appreciable, but during times when the line is lightly loaded the effect on the lighting system is very noticeable.

The motor in getting up to speed makes considerable noise, and even when running at normal speed is more noisy than desirable. The company making it claim they will in a short time be able to place on the market a machine that will act more satisfactorily, but there is room for a considerable improvement before this outfit will approach the smoothness of operation of the multi-phase machine above mentioned.

We hope to see many improvements in the design of alternating-current apparatus, and, as stated in the first part of this paper, we should co-operate in encouraging the manufacturers in making apparatus that will suit all conditions of service.

Unless we are prepared to make considerable reductions in the price of current we must get this class of business by removing every possible waste, increasing the output of each machine and improving the operation of them by the application of devices that can be operated electrically and automatically.

While investigating the progress made in the manufacture of alternating-current elevators, the improvements in the electric traction elevator were brought to the writer's notice. A word at this time, while somewhat outside of the scope of this paper, might not be amiss regarding high-speed electric elevators for office buildings.

To-day in the larger cities the use of electric elevators has increased to a very large extent, so that owners and builders of high buildings seriously consider, and very often favourably, the installation of electric elevators instead of hydraulic. Not only the first cost is less, but the electric elevator has been perfected to such an extent that the smoothness of operation compares favourably with all types of hydraulic elevators, not only for local but for express service either in dry goods stores or office buildings.

The traction elevator has practically solved the high-speed, high-lift, electric elevator problem, and while there will no doubt be many improvements in electric elevators in the future, still this type of elevator is bound to have a great influence in favour of central station service in office buildings and stores in our large cities, owing to smoothness of running and economy of operation.

The traction elevator can be placed either on the roof of a building or in the basement, whichever is the most desirable and economical, taking up little space in either location. The main objection to the traction elevator to-day is that it is not quite as economical in the consumption of current as the drum type of elevator, owing to the very low motor speed and correspondingly large size of the motor.

The present motor for this type of elevator has a speed of from 60 to 100 revolutions per minute. To make a commercial piece of apparatus of this speed, the efficiency of the motor is sacrificed to some extent. Necessarily the size of a motor of this speed is larger than of the standard commercial motor, and the shop and material costs are greater.

Experiments are at present being made with high-speed motors for traction elevator work, and the prospects of obtaining satisfactory results look very bright. If this feat is accomplished it will further reduce the initial and operating cost of the traction elevator.

The drum type of machine has been improved greatly in the past few years. The magnet control has had a wonderful influence on the smooth running of machines of this type. The electric brake has also been improved, and this type of brake is not only now applied to the worm shaft, but is also applied internally to the drum itself in such a way that it greatly increases the smoothness of the operation of this type of elevator in stopping, thus permitting the operation of drum types of elevators at high speed, and, according to the manufacturers, up to 400 feet a minute.

More strenuous missionary work among architects and owners of buildings about to be erected, with information of the proper sort in regard to electric elevators, would go a long way towards increasing the popularity of this type of machine. The elevator companies are in this position: they are able to build any type of machine, and it makes little difference to them whether or not the customer uses central station service. It is up to the electric light companies to take hold of the situation in a methodical manner, obtaining accurate information regarding the cost of operation of different types of elevators. There have been many figures submitted regarding these costs, but the writer believes the subject will stand closer investigation.

With the advance in the design and manufacture of electric elevators, placing this machine on a high plane, it seems to the writer that enough evidence could be secured so that we would not be afraid to present the true costs of operation to our customers with great advantage to ourselves.

Municipal Ownership

By ARTHUR WILLIAMS

From a Paper Read at the Recent Convention of the Association of Edison Illuminating Companies

AT the moment it is probably true that the municipal ownership movement in this country is a mere political expedient. Yet in the cause, as it has been presented, there is much of an attractive nature, and danger is not lacking that the movement may become a fixture in the government of American municipalities. Men are wont to look kindly upon any public measure that promises to relieve the tension on their pocketbooks. And in advocating municipal ownership politicians have a rare chance to pose as public benefactors.

A POSSIBLE DANGER

Familiar with the ways of politicians in endeavouring to attract and hold public opinion, and knowing the shameless methods of those most prominently identified with this movement, we have, perhaps, undervalued its strength. In this may lie an element of danger. It is said Napoleon's battles were won by overestimating rather than under-estimating the strength of his enemies.

England is looked upon as the home of municipal ownership, which indeed it is. Owing to the similarity of language and our greater familiarity with her institutions, we are, perhaps, better informed concerning, and more greatly impressed by, what is taking place in that country. The same movement, however, has extended to the Continent, in some parts of which it has made equal or greater headway. In the city of Vienna, for example, the municipal investment in the electric light and tram works,—two great generating stations standing side by side,—exceeds ten millions of American money.

Behind this movement, wherever it has occurred, there must have been a cause, and its present existence and continued extension must be due to the approval of the public. The original cause probably was an unsatisfactory service rendered by private corporations,—in many instances, at least, the result of short-term franchises and high tax rates. For political reasons the defects may have been magnified or unduly emphasized. But there must have been some foundation upon which to build.

INADEQUATE PUBLICITY

There may also have been inadequate presentation of the corporation's side, in seeking to enlighten and win public opinion. The great public has been likened to a jury which can give a verdict only on the evidence before it. Thus, a poor case fully presented may prevail over a good case where the presentation is insufficient.

Many public service corporations of European cities are to-day giving wretched service, owing to the approaching expiration of their franchises. The defects in the service, with which the public is familiar, are constantly referred to and advanced as complete justification for the termination of the franchises and the forfeiture of existing property and public rights and the substitution of public instead of corporation ownership.

How often does one find the side of a corporation fully and fairly presented; its cause pleaded or its position explained; the hidden conditions brought to light; the overlooked or forgotten elements of cost revealed; the experience of other communities compared? Were these things done, how different might be the direction of public opinion.

RESULTS OF AROUSED PUBLIC SENTIMENT

One of the best examples of the value of aroused public sentiment resulting from a campaign of publicity is that offered by the city of Cleveland, in comparing the results of the vote there upon the question of municipal ownership, with the cities of Detroit, Chicago and San Francisco.

In 1893 Detroit passed upon the question, 27.55 per cent. of those voting favouring, and 2.24 per cent. opposing, municipal ownership; in 1902 in Chicago 27.39 per cent. favoured and 4.18 per cent. opposed; in 1903 in San Francisco 11.13 per cent. favoured and 8.36 per cent. opposed; while in Cleveland in 1903, 21.69 per cent. favoured and 27.29 per cent. opposed municipal ownership.

In making these comparisons it will be appreciated that there is no suggestion of criticism. It is much easier to arouse public sentiment today upon this question than it was a year ago, and doubtless it will be far easier next year than it is now. Further, there is now a large amount of accumulated material upon which to make an effective defensive campaign which even two or three years ago was not in available form.

H. T. Newcomb, in his excellent analysis of the matter, states:*

"It is altogether likely that the latent spirit of conservatism was just as extensive in Detroit, Chicago, and San Francisco prior to these more or less complete expressions of popular ideals and purposes as in Cleveland, and that the chief difference is really in the degree in which the dormant opposition to radical departure from the governmental practices which have the approval of American experience was aroused and made effective."

A CAUSE COMMON TO ALL

Public action by private corporations should be carefully considered, and well directed. It should be united, since the cause of one is the cause of all, and the conditions controlling one surround all. While united and co-operative, it should be individual, personal, direct and local. Helping all the others by example and experience, each must do its own work in its own field of operation.

Educational publicity without, and the attainment of higher ideals within, are concededly the effective ways of meeting this movement. No others are needed; no others should be wanted. Quick, perhaps, to see the defects in others, we should apply a magnifying glass, with searchlight rays, to our own methods and relations with the public.

SOME ESSENTIALS OF PUBLIC POPULARITY

A first essential is that courteous, considerate treatment which the public so thoroughly appreciates and enjoys. Compare what we can do with the brusque indifference of the employees in almost every department and office of a municipality. Our own methods, instead of resembling them, should stand out in marked contrast. The beginning should be with the directors and president, and it should extend through the entire organization to the office boy and janitor.

The quality of the service should be as nearly perfect as modern invention, construction and operation can make it. Bad, indifferent, or poor service should be corrected at any cost. More should be given, not less, than the public has been led to expect. What we are to the public makes good opinion or bad, friends or opponents.

Good service means not alone the kind of light we supply,—it includes everything relating to the affairs of the company: the manner with which poles are erected and wires are strung; with which streets are opened and the pavement again laid; the promptness with which customers' wants are met; with which service interrupted is restored; the convenience and promptness with which the public may become users of electric current.

The complaint bureau of a public service corporation cannot be too highly rated. Every complaint made gives an opportunity to make a new and lasting friend,—the kind it pays to have,—one who has been cured of a grievance. It is not that a rebate has been made or an employee discharged, but the manner in which the complaint is received and the evidence of careful consideration that counts with the public.

CONSIDERATION TO EMPLOYEES

Another very important consideration is the treatment which private corporations accord to their employees. There is probably little question but that a large percentage of those whose votes must be relied upon in any municipal ownership or socialistic movement are the employees of public service corporations. In 1903 there were more than one million three hundred thousand employees in the service of American steam railways alone; the number is undoubtedly greater today. Thus in this single service alone are more than 10 per cent. of the voters of the country.

The highest wages are now paid by the private corporations. But there is something more than wages to which employees are entitled:—The conveniences with which they are surrounded; the care and protection accorded them; the appreciation of their work,—for they are a part of every success their employers achieve; the assistance rendered during illness; reading and meeting rooms and other means of entertainment; and pensions for old age.

Many street railway companies now provide, at convenient points, meeting rooms in which are billiard tables and other forms of recreation. The employees of one company conduct a magazine, in which recently was an article by James Dalrymple, of Glasgow, and one will soon appear by H. T. Newcomb, whose work against municipal socialism has been of such an important nature.

The Pennsylvania Railroad Company continues, as long as they shall live, a pension to its employees after reaching a predetermined age and rendering a certain number of years of continuous service. It is said that

* From Municipal Socialism—The Conservative Victory in Cleveland, by H. T. Newcomb.

since the adoption of this system strikes have become unknown and the men are absolutely loyal to the company.

PRIVATE PREFERABLE TO GOVERNMENT EMPLOYMENT

At the recent summer meeting of the American Association for the Advancement of Science, H. T. Newcomb brought out quite clearly that to the employees private was far preferable to public employment. He states in that connection:—*

"I propose to prove not only that the government is not the best employer, but that it is not even a fair employer. Nor is this all. I shall show conclusively that when government engages in industry on a large scale the condition of its employees naturally and inevitably degenerates to that of slavery."

He then proceeds to make good this challenge, as he calls it, by showing that while from 1896 to 1904 the average cost of food in this country had advanced nearly 17 per cent., and while during that period the average rate of wages in private employment had increased something over 17 per cent., there had been no increase at all in the wages of government employees.

Comparisons in the government printing office are only available since March 3, 1899. Since then, however, the cost of food has increased more than 12 per cent. and the wages of printers in private establishments have been raised from 12 per cent. to 22 per cent., though no advance has been allowed the employees of the government printing office.

THE RATE QUESTION IN THIS MOVEMENT

With all other considerations the prices of our companies must be included. Not only should they be as low as circumstances justify, but as simple and as readily understood. Differential are not preferential rates. But this it is sometimes difficult to make the public understand.

While a differential rate is the more equitable method of charging for electric current, under municipal ownership the more simple flat rate would probably prevail. The government sets an example in a two-cent postage stamp,—whatever the distance. Manifestly does it seem unfair to charge as much to deliver a letter a half dozen city blocks as, say, between New York and Chicago. Yet this the government does,—and probably in the general good few could ask a change.

* "Public Ownership and the Wage-Earner."

SLIDING SCALE AS A PUBLIC POLICY FACTOR

One method of charge for public service,—gas and electric,—now receiving a great deal of attention might be mentioned,—the English sliding scale, recently adopted by the gas companies of Boston. The method seems to contain elements in satisfying the public which no other rate system thus far devised appears to have accomplished. After assuring to the company a fair return upon its investment, and the public a maximum price beyond which it shall not be charged, the further profits are divided, in ratios agreed upon, between the public and the company.

How the plan is looked upon by an outsider may be understood in the following editorial paragraph taken from "Collier's Weekly," August 4, 1906:—

"The Boston Consolidated Gas Company on the same date (July 1, 1906), acting on the sliding scale introduced through the energy and intelligence of the Public Franchise League in its three years' fight, reduced the price to 85 cents, a drop of 15 per cent. and a direct saving to the public for the coming year of $562,500.

"The gas company, under its present exceptionally liberal-minded management, accepts enthusiastically the sliding scale and speaks of itself as in partnership with the public, by which the gain of either, under the new law, means the gain of each. Unusual, indeed, is it for a corporation to state in an advertisement that the 'immediate effect' of a drastic law made for its regulation 'is another reduction in the price of gas.'"

FAVOURABLE OPINION BASED ON MISLEADING INFORMATION

The members of this association do not need to be told that public opinion to-day, where favourable to municipal ownership, is based upon information of a very misleading nature. In his memorable address before the National Electric Light Association at Atlantic City last June,* Everett W. Burdett shows that the reported profits of municipal plants in England, so widely advertised here, are accounted for by the fact that the amount set aside for depreciation averages only 2/10 of one per cent. upon the investment. Even this small sum would entirely disappear were the municipal plants charged with taxes, direct and indirect, commensurate with those paid by private corporations operating under like conditions.

But loss of investment and increased taxes are not the most serious considerations which have entered into this development in England. Of far more serious import is the restricted growth of the industries of Great Britain compared with those of other countries. This Mr. Burdett characterizes as worse than a failure,—as a calamity. Permit me to quote him on the subject:—

"But in one respect municipal ownership in Great Britain has been worse than a failure,—it has been a calamity. Owing to the restrictive character of the laws, particularly the Electric Lighting Acts of 1882 and 1886 and the Tramways Act of 1870, the electrical industry in Great Britain has been hampered and restricted to such an extent as to make the showing lamentable. So serious had this become in 1902 that the council of the Institution of Electrical Engineers of England appointed a committee 'to determine whether they can recommend the council to take any action, and, if so, what action, that would assist the industry.' After a most elaborate investigation and the taking of much testimony, the committee of the council resolved: 'That notwithstanding that our countrymen have been among the first in inventive genius in electrical science, its development in the United Kingdom is in a backward condition, as compared with other countries, in respect of practical application to the industrial and social requirements of the nation.' And this result was attributable principally to the operation of laws expressly designed to encourage municipal and discourage private enterprise. The committee of the council of the Institution of Electrical Engineers expressly attributed the unsatisfactory results to what they determine 'the restrictive character of the legislation, governing the initiation and development of electric power and traction undertakings and the powers of obstruction granted to local authorities,' which they allege to be the 'essential difference between the electrical industry as it exists in the United Kingdom and as it exists abroad."

* "The Agitation for Municipal Ownership in the United States—Its Origin, Meaning and Proper Treatment."

INDICATIONS OF A REACTION IN ENGLISH PUBLIC SENTIMENT

England's municipal indebtedness, according to the last available figures, now amounts to £2,345,000,000, and there is evidence of a strong counter-movement looking to the material curtailment of the functions of the municipalities.

Lord Avebury, in a recent address, pointed out that the capital expenditure in the electric lighting undertakings alone now amounts to £27,000,000, upon which last year a "profit" was claimed of £339,000; that only 1 per cent. was allowed for depreciation, which he called absurd. If as little as 2½ per cent. had been set aside for depreciation, he says, this item alone would have amounted to £673,000 and "would have turned the so-called profit into a heavy loss." He also pointed out that of forty-eight municipalities working tramways only thirteen contribute to the rates; seventeen make no depreciation allowance, and only eleven make over 2 per cent.

In an address before the London County Council, Lord Goschen is credited with having said:—

"Extravagant expenditure, accumulation of debt, the invasion of field after field of private enterprise, consequences which I feared for the executive government, have dogged the footsteps of municipal administration. In no direction have blows more serious been struck at the very foundations of private enterprise."

Sir Felix Schuster, before the Industrial Freedom League of England, protesting against the extent to which municipalities of his country have engaged in private enterprise, says:—

"Private enterprise is, after all, the backbone of our industries, to which nearly everything great that has been done in this country is due, and on private enterprise, we believe, the future of our trade, of our commerce, and of our public life depend."

Lord Avebury, before the same body, gave five reasons against municipal trading:—

(a) That the legitimate functions and duties of our municipalities are already enough.

(b) Municipal trading involves an immense increase in municipal debt.

(c) It involves municipalities in labour disputes.

(d) There is not the same stimulus to economy and attention.

(e) Municipal trading is a serious check to progress and discovery.

FURTHER EVIDENCE OF GROWING DISSATISFACTION WITH ENGLISH CONDITIONS

At Bristol careful investigation is now being made into the conduct of municipal trading enterprises. Featherstone Witty, speaking before the Industrial Freedom League, describes them as being in a most unsatisfactory financial state. After careful investigation, as a member of a commission appointed for that purpose, he says, with regard to municipal trading generally in Bristol, that the results from a financial point of view have been very disappointing to the ratepayers; that the electrical as well as the dock enterprises of the city have been carried on "on financial principles which leave much to be desired from the point of view of soundness."

The Parliamentary Electric Lighting Act stipulates that an undertaking established under it shall provide a reserve fund with a portion of its surplus, and that this reserve fund shall be invested outside of the undertaking itself in approved "trustee securities." During his investigation, Mr. Witty found that the sum of £5000 had been allowed as a reserve fund; when asked where it was invested, he was told "in the unexhausted borrowing powers of the committee." "That is to say," continuing to quote Mr. Witty, "supposing the committee had authority from the Local Government Board to borrow £100,000, it registered a self-denying ordinance in its minute book that instead of borrowing £100,000 it would borrow only £95,000." This is the way the reserve fund of £5000 has been "invested."

LONDON'S MUNICIPAL FERRIES AND TRAMS

Under the title of "Some Lessons in Municipal Trading," "Engineering," of London, of August 3, 1906, is responsible for the statement "that in view of the County Council elections next spring an organized campaign is to be undertaken to awaken the electors of London to a due sense of their responsibility in connection with the administration of the municipal affairs of the metropolis." The same article points out that during the first year of the municipal steamboat service on the River Thames the receipts fell short of the working expenses by £50,095,—$250,000. The expenditure for this service is placed at £293,136,—$1,465,000. As the receipts fell short of the working expenses, it is to be presumed that no allowance was made for depreciation, which at the moderate allowance of 7½ per cent. would amount to an additional loss of $109,926, or a total loss of more than $360,000.

The same authority points out that, according to the annual report of the London tramways, the surplus balance is £31,249,—$156,000, —on a capital expenditure of over £3,000,000—$15,000,000. This is one-tenth of one per cent. upon the investment, for which, presumably no depreciation or reserve funds have as yet been accumulated. Notwithstanding a showing so pitifully inadequate the London County Council intends to expend £756,000 for additions and equipment during the year to come.

All reports agree that the course pursued by the London County Council in its extravagant and venturesome entrance into the field of private industry is creating a strong counter-current of public sentiment, which will undoubtedly cause marked reaction in the not distant future.

TIMELY WORDS FROM AN AMERICAN ABROAD

As this paper is about ready for the press, reports have been cabled to the effect that Mayor McClellan, of New York City, now making an extensive foreign tour, has said that his observations abroad convince him there is nothing in municipal ownership for the American people. He states that the conditions are most unsatisfactory, and, with the possible exception of those prevailing in the street railways of Glasgow, they are such as the American people would not tolerate for a moment.

With the matter pressing upon him from every hand, it is but natural that Mr. McClellan would be interested in the question of municipal ownership, wherever that question has found expression in practical application. The Mayor cannot be said to be an opponent of the movement, as is well evidenced by the fact that the lighting on one of the large bridges of New York City was undertaken as a general step in that direction during his administration, and, at the same time, under the same authority, the most important municipal ferry in this country was placed in operation.

In concluding, I will quote in full Lord Avebury's fifth reason why municipalities should not become competitors with private enterprises:—

"Different trades are being attacked, one by one, and unless they unite, will be destroyed one after the other. Governments and municipalities cannot work as economically as private enterprises, and it follows that municipal trading must increase our rates more and more, while at the same time it raises the price of necessaries, so that it cuts down incomes with one hand, and with the other makes life more expensive. In the long run the artisans and labourers will be the greatest sufferers: the check to enterprise will mean less demand for workmen and lower wages, while everything they require will cost them more."

New Lamps and New Opportunities

By FRANCIS W. WILLCOX

From a Paper Read at the Recent Convention of the Ohio Electric Light Association

THE present period marks a most important development for the electrical industry. The limitations of the ordinary carbon filament incandescent lamp have been removed through Dr. Whitney's discovery of metallizing or graphitizing carbon. This has given a practical lamp of 2½ watts per candle without any loss of life over the present 3.1 w. p. c. lamps and the promise of still greater gains.

The discovery and utilization of certain new metallic substances for filaments gives a practical lamp of 2 watts per candle in the tantalum lamp, and possibly still higher efficiencies in other lamps under development.

The Gem or metallized filament and the tantalum lamp are now both on the market at prices far below their value to consumers, and stand ready to give the aid central stations have long required and desired from higher efficiency incandescent lamps.

So then we have before us an opportunity,—not a theory,—a very pressing, practical and important opportunity, which is the immediate adoption of these higher efficiency lamps and their introduction into service to replace present incandescent lamps (now obsolete) as rapidly as it is possible to obtain them.

This movement should not be deterred by the possibilities of still higher efficiency lamps to come, for the incandescent lamp is a renewal device of low cost and must be replaced by one of its own kind or something better. Exchanges can, therefore, readily be made to improved types without any sacrifice.

Neither should the movement be deterred by the fear that higher efficiency lamps may cause an immediate reduction of income. Act as promptly as a company may, they will hardly be able to introduce the new lamps fast enough to cause any immediate material reduction of income, and the improvement in business resulting from the adoption of the new lamps will offset any tendency towards income reduction.

Let no central station attempt halfway measures or lose the prestige of having first introduced and supplied the new lamps to their consumers. The central station must be an eager and willing leader in such matters and not a constrained or hesitating follower. Of course, the change to higher efficiency lamps involves added costs and perhaps some temporary loss of income, but the change should nevertheless be definitely and decisively made.

There should be no question as to the ultimate result, if we can judge by experience. The introduction of higher efficiency lamps is the equivalent of a reduction in rates, and the same effects should follow from each. What does experience show results from reduction in rates intelligently made? Does it not show material growth of business and greater net earnings? This, at least, is the result that is stated to the writer. Electric service appears of recent years to have received its greatest impetus as a result of the adoption of low rates (made under new, profitable rate systems).

An Eastern manager in business for many years with an aggregation of lighting companies, told the writer that experience had demonstrated to him that more money could be made at reasonably low rates than at higher rates, and that the policy of keeping up rates which his companies had advocated and followed for many years would be entirely reversed if they had to do it over again.

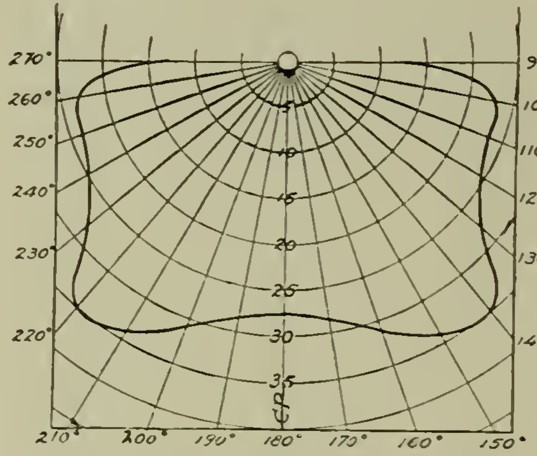
POLICY AND METHOD FOR INTRODUCING THE NEW LAMPS

Before proceeding further it will be desirable to describe the method of rating adopted for and values given by the new lamps.

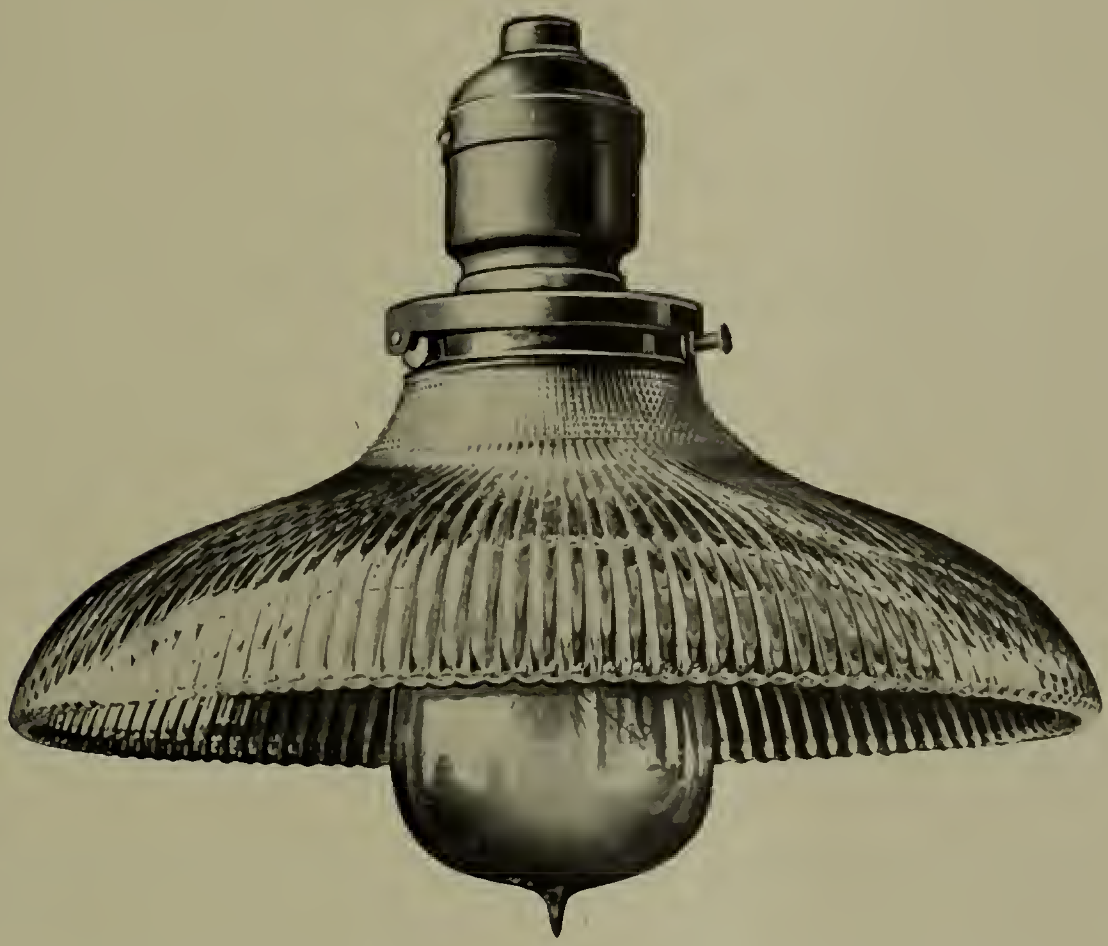
The new Gem filament lamp has been standardized at 50 watts, thus giving the improvement in the form of an increase in candle-power of 25 per cent., or from 16 to 20 candle-power, instead of a reduced wattage to 40 watts per lamp. The price of the lamp has been increased in the same proportion, so that the renewal cost per candle-power per kilowatt-hour has not been changed.

A 22-CANDLE-POWER, 44-WATT TANTALUM LAMP WITH DISTRIBUTING FORM OF REFLECTOR, MADE BY THE GENERAL ELECTRIC COMPANY, HARRISON, N. J.

On the label for the Gem lamp the total watts are substituted for the candle-power rating heretofore shown on labels. This does not mean that candle-power ratings or values will be abandoned; such a course is not



CURVE SHOWING LIGHT DISTRIBUTION OF A TANTALUM LAMP WITH A DISTRIBUTING FORM OF REFLECTOR desirable, nor possible even if desirable. Candle-power values will continue to be used and referred to, but when given will be fully defined. As a lamp is capable of being rated in candle-power in several ways, horizontally, spherically, down-

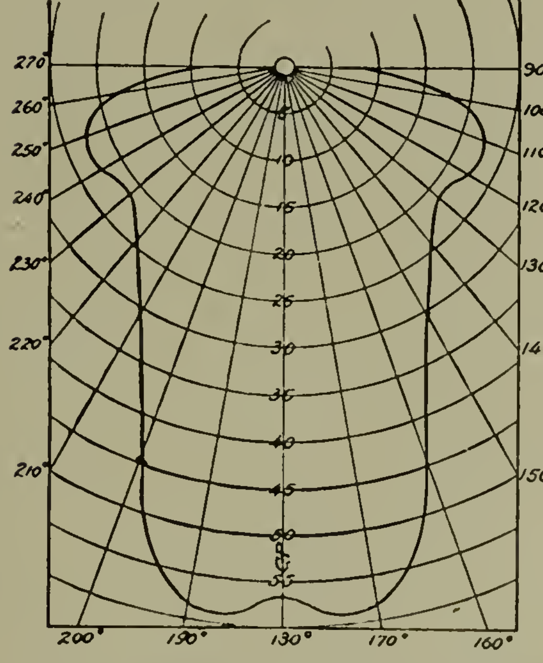


GENERAL ELECTRIC TANTALUM LAMP WITH CONCENTRATING FORM OF REFLECTOR

ward values from varied forms of reflectors, etc., the omission of any candle-power rating from label seemed desirable to avoid confusion.

After all, as electric metering is generally done on the kilowatt-hour basis, the practical unit is really watts per lamp instead of candle-power. The plan has, besides, many advantages:—

It allows even watt ratings per



CURVE SHOWING LIGHT DISTRIBUTION OF A TANTALUM LAMP WITH CONCENTRATING FORM OF REFLECTOR

lamp, such as 50, 30, 20, etc., instead of the fractional ratings now existing on many sizes.

It insures a more uniform appearance and a more uniform performance of individual lamps by reason of the even degree of incandescence or efficiency at which a filament so rated will burn.

It permits central stations to gradually advance their standard of efficiency from time to time to meet changing conditions.

The voltage markings are arranged in a vertical column in steps of two volts apart. These voltages are known as the "top," "middle" and "bottom," or first, second, and third voltages (V1, V2, and V3).

As is well known, any one lamp will vary in its candle-power and watt ratings with increase and decrease of voltage. The arrangement shown, therefore, permits three ratings for the lamp, as shown in the following table:—

TABLE OF VALUES OF GEM 50-WATT LAMPS AT FIRST, SECOND AND THIRD VOLTAGES

Voltage of Circuit	Total Watts	Mean Horizontal Candle-Power	Watts Per Candle	Average Useful Life
"Top" or first voltage (V1), 114	50.	20	2.5	450
"Middle" or second voltage (V2), 112	47.5	18	2.65	640
"Bottom" or third voltage (V3), 110	45.	16	2.8	940

From the data given in the foregoing table each lighting company can determine what course it should adopt.

Central stations now using 3.1 w. p. c. lamps would naturally adopt the new lamps at full efficiency (top voltage) and thus keep their watt consumption per lamp unchanged. While the total cost of lamp renewals would be increased somewhat on this basis, the added charge is a small one to pay for the ability to give consumers 25 per cent. more light for the same revenue.

Central stations now using 3.5 w. p. c. lamps could opportunely adopt the new lamp in the middle or second voltage. This would share the improvement with the consumer, giving 12 per cent. more light with 15 per cent. less wattage. The total cost of lamp renewals, which is very low for the present 3.5 w. p. c. lamps,—only about one-third cent per kilowatt-hour,—would be only slightly increased, and there is hardly a lighting company that could not profitably afford to make the change to at least this intermediate efficiency of the new lamps. Its useful life, 750 hours (with average life materially longer), is commercially sufficient, as it is equal to that formerly given by 3.5 w. p. c. lamps. The life of 3.5 w. p. c. lamps is at present too long for the most economical service and could with advantage be shortened to correspond with that given by the new Gem lamp in middle voltage.

SUGGESTIONS AS TO RENEWALS

If anyone doubts whether free lamp renewals are desirable, or if the practice is well established, let him consult the 1906 National Electric Light Association Question Box on this point (pages 250 to 260). The answers to a number of questions on lamp supply and renewal policy shows overwhelming testimony in favour of free and liberal renewals. Indeed, practice goes much further in many instances, and furnishes not only free lamps, but is now giving free signs to burn them in, and experience shows that this pays handsomely.

With the advent of the new Gem lamp, the importance of central station direction and control of the lamps used is greater than ever. Full and complete control is obtained only with free renewals, and the adoption of a free renewal policy (where not now in vogue) could, therefore, most opportunely be made with the introduction of the new Gem lamp. In any event, it is specially important that the new lamp should be favoured with equally as liberal a policy as the present lamps.

Companies now giving free renewals of the present lamps should do likewise for the new lamp. Companies now charging for lamps should supply the new lamp without any increase of price.

Unless the policy for the new lamp be at least as liberal as that for the present lamps, the introduction and general use of the new lamps is apt to be retarded.

THE TANTALUM LAMP

The tantalum lamp is now manufactured in this country, and has been listed at a price of 75 cents each, or 60 cents net in lots of 500.

The lamp is at present supplied in but one size,—about 44 watts, giving 22 mean horizontal candle-power (English Parliamentary standard) and with a useful life on direct current of 700 to 800 hours. Unfortunately, the life on alternating current is only about one-third of this value,—too short to be commercial.

While the first cost, say 60 cents, of this lamp seems high, if we prorate the useful life on direct current, —750 to 800 hours,—on an equal basis with that of the ordinary 3.1 w. p. c. carbon filament lamp, we find that it is reduced to about 40 cents. This is only about 25 cents more than present 3.1 w. p. c. lamps cost, and companies now supplying free renewals of the latter could furnish renewals of the tantalum at 25 cents each without any increase of renewal costs. This would give consumers the chance to use tantalum lamps at no greater costs than are paid for a Welsbach mantle, and thus place the electric service with the tantalum lamp on an excellent competitive basis with Welsbach lamps.

TANTALUM UNITS

The tantalum lamp, by reason of the relatively small end candle-power and the fact of their burning to better advantage in a vertical position, can be used to marked advantage in the form of a "unit" with a suitable Holophane reflector.

In Table I. is given the cost of an equal amount of light (1000 candle-hours) with tantalum (at 2 w. p. c.), Gem filament (at $2\frac{1}{2}$ w. p. c.), and ordinary carbon at 3.1 and 3.5 w. p. c., including cost of renewals in each case and power at various rates per kilowatt-hour shown.

From these results it can be seen, at straight costs per kilowatt-hour for current and an equal amount of light, just how the different lamps stand.

It should be noted that in spite of its high renewal cost, the tantalum lamp gives the lowest cost of any of the lamps, above 3 cents per kilowatt-hour. With free renewals of

TABLE I.—COST OF 1000 CANDLE-HOURS OF LIGHT IN CENTS, INCLUDING COST OF POWER AND LAMP RENEWALS

For Different Lamp Efficiencies at Various Rates per Kilowatt-Hour

Rates per Kilowatt-Hour in Cents	Ordinary Carbon Lamp, 3.5 W. P. C.	Ordinary Carbon Lamp, 3.1 W. P. C.	Gem Lamp, 2.5 W. P. C.	Tantalum Lamp, 2.0 W. P. C.
1	4.5	5.1	4.5	5
2	8.0	8.2	7.0	7
3	11.5	11.3	9.5	9
4	15.0	14.4	12.0	11
5	18.5	17.5	14.5	13
6	22.0	20.6	17.0	15
7	25.5	23.7	19.5	17
8	29.0	26.8	22.0	19
9	32.5	29.9	24.5	21
10	36.0	33.0	27.0	23
11	39.5	36.1	29.5	25
12	43.0	39.2	32.0	27
13	46.5	42.3	34.5	29
14	50.0	45.4	37.0	31
15	53.5	48.5	39.5	33
16	57.0	51.6	42.0	35
17	59.5	54.7	44.5	37
18	64.0	57.8	47.0	39
19	67.5	60.9	49.5	41
20	71.0	64.0	52.0	43

ordinary carbon lamps and free renewals of Gem filament lamps and tantalum lamp renewals at 25 cents, as suggested herein, the resulting cost for an equal amount of light at various rates per kilowatt-hour will be for the different lamps as shown in Table II.

TABLE II.—COST OF 1000 CANDLE-HOURS OF LIGHT, IN CENTS, WITH FREE RENEWALS OF ALL LAMPS EXCEPT TANTALUM, FOR WHICH A RENEWAL CHARGE OF 25 CENTS IS MADE

Rates per Kilowatt-Hour, in Cents	Ordinary Carbon Lamp, 3.1 W. P. C.	Gem Lamp, 2.5 W. P. C.	Tantalum Lamp, 2.0 W. P. C.
1	3.1	2.5	3.25
2	6.2	5.0	5.25
3	9.3	7.5	7.25
4	12.4	10.0	9.25
5	15.5	12.5	11.25
6	18.6	15.0	13.25
7	21.7	17.5	15.25
8	24.8	20.0	17.25
9	27.9	22.5	19.25
10	31.0	25.0	21.25
11	34.1	27.5	23.25
12	37.2	30.0	25.25
13	40.3	32.5	27.25
14	43.4	35.0	29.25
15	46.5	37.5	31.25
16	49.6	40.0	33.25
17	52.7	42.5	35.25
18	55.8	45.0	37.25
19	58.9	47.5	39.25
20	62.0	50.0	41.25

During last winter the intake canal of the Niagara Falls Power Company was kept free from floating ice by means of a trolley boat 25 feet long and 10 feet beam, operated by a Westinghouse single-phase railway motor supplied with current by double trolley wires running the length of the canal and provided with an over-running trolley and flexible cable. The ice was broken by the boat and driven toward the overflow near the head-house.

Communication by Electricity in the British Army

AMONG the most striking changes in the organization of field units of the Royal Engineers of the British army, says "The Electrical Engineer," of London, are doubtless those referring to telegraph companies, whose importance in modern warfare is now generally recognized. At present there are three field telegraph companies. The new establishments provide for one line of communication telegraph company, two air-line, two cable, two wireless, and six divisional telegraph companies. Of the six divisional companies only three units and three staffs will be maintained at home in times of peace. Of the searchlight companies, one unit divisible into two sections will be maintained, a section to comprise two plants, each complete with generator and projector, or four plants in all for the unit.

Electric Freight Service in Chicago Tunnels

ON August 15, underground freight service was begun in the tunnels of the Illinois Tunnel Company. The first trip was made over a distance of two miles, and occupied 16 minutes.

About forty-five miles of the tunnel are now completed, several branches extending well beyond the river on the North and West sides. The tunnel company now is equipped with 67 electric locomotives and 400 freight trucks, and an additional complement of 15 locomotives and 250 trucks is now being built.

The company has forty receiving stations and is connected with nine regular railroads. The roads now ready for service are the Erie, Alton, Rock Island, Wabash, Santa Fe, Great Western, Monon, Baltimore & Ohio, Milwaukee & St. Paul, and contracts have just been entered into between the tunnel company and the Chicago & Eastern Illinois and the Illinois Central.

It is announced that the Lackawanna Railroad will in the near future operate its trains by telephone in connection with its automatic block-signal system over the entire line, including branches.

A railway telegraph school is to be opened by the Atchison, Topeka & Santa Fe Railway at Topeka, for the purpose of recruiting students to be trained for telegraph operators and agents.

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The Corporation and the Public

By WM. H. BLOOD, JR.

IT was only a few years ago that the manager of the electric corporation devoted the greater portion of his time and energy to engineering problems. Matters of detail in the selection of apparatus and systems were to him of paramount importance. The success of his enterprises depended, he thought, on his ability to decide aright between a two-motor and a four-motor equipment for his cars, or between a direct-current and an alternating-current system of lighting. Such problems as these gradually solved themselves as the "art progressed" and as the manager acquainted himself with his requirements.

The next step in the process of evolution was in economy of operation. The manager was bending all his energies to save even a tenth of a cent in turning out his kilowatt-hours. Direct-connected generators were installed, turbines were contemplated, water-tube boilers with mechanical stokers were regarded as important, and the entire plant was put upon a more efficient basis.

During the last year or two the commercial side of the business has been emphasized. Engineering matters the manager now leaves to his trained electrical or mechanical engineers. Questions of operation his superintendent cares for; but his personal attention is required on matters of advertising, soliciting and all forms of business getting.

Co-operation is the watchword today, and the manufacturer, the solicitor, and the advertiser are working together with one object in view,—that of getting additional business.

While the manager has been revamping his plant, improving his operating conditions, increasing his business, and, in many ways, perfecting his property, he has been careless in his dealings with the public and oftentimes his *laissez faire* policy, or perhaps lack of any policy at all, has now brought him face to face with serious complications.

No one likes to be ignored and the public at large is very sensitive in this respect. The people, the politicians and the newspapers have, for years, been demanding all sorts of possible and impossible things of the companies, and the companies have for the most part taken this abuse in very much the same way a stupid dog takes his whipping. They have cringed, acted as though guilty, and have tried to keep out of the way.

Very few companies have stated their side of the case; fewer still have taken the public into their confidence. It is a common occurrence for the companies to be misrepresented and maligned, and it is a rare thing for one of them to take the pains to correct the perverted facts or to nail the malicious lies. Why are the companies so cowardly? Is it not about time for them to be a little aggressive and to present their case to the people?

In most instances, the company is in the right and has all the facts and figures at its command to prove this, but rather than get into an argument or to "avoid stirring up the matter" it says nothing and the people at large believe what they see printed in the sensational papers, particularly as it remains uncontradicted. The companies are by no means perfect and the points wherein they fall short should be corrected before the public will take the corporations seriously or believe in their honesty.

The organization of a large corporation is complex; the officials are not in touch with the real people, and the higher an official is the less, as a rule, he comes in contact with his patrons or knows of the details of their grievances.

Arbitrary rules are common—circumstances do not alter cases. The big corporations, like the Pharisees of old, live up to the letter of the law, and so long as they are working within their corporate rights they think they are doing no evil. Is that, however, all the public service corporation should do? Are not moral obligations as important as contract requirements? Is it good policy for a company to ignore the ruling of an inferior court simply because the attorneys say that they have the right on their side and that the upper court will reverse the decision of the lower?

Is it right to beat the people over their heads and throw them off the cars simply because they will not pay a second fare? Is not such treatment of the public, to say the least, unjust and entirely uncalled for? Could not better results have been accomplished in other ways and with much less offense? Not only does this company suffer on account of such short-sighted policy, but the cause of corporate management of public utilities at large is injured and municipal ownership is given an excuse for existence.

A lighting company with a large income is perhaps supplying the city with street lights. The city desires to renew the contract but holds that the price of ten years ago is too high. The company says, "Oh, no. That is our price. Take it or leave it." What course is there left for the city but to establish its own plant?

Suppose, if you please, that the income which came to the company from lighting the city's streets was only 2 or 3 per cent. of its total business; the company could, from a business standpoint, better afford to give the service to the city free rather than to allow the establishment of a municipal plant. And what of the effect of this action on the other cities of the country? Is it not establishing a bad precedent, and do not all other companies in the country have to suffer for the indiscretion of this one?

A lady desired to take the train from A to B, and the following conversation ensued:

Lady: "I should like a lower berth on the sleeper from A to B to-night."

Clerk: "Have none."

Lady: "None at all? Then I will take an upper."

Clerk: "Have no uppers."

Lady: "No uppers?"

Clerk: "That's what I said. Train all sold."

Lady: "Well, then I suppose I shall have to wait over another day. Let me have one for to-morrow night."

Clerk: "Nothing doing to-morrow night either."

Lady: "You mean you have no accommodations for to-morrow night either?"

Clerk: "That's what I said."

Lady: "Well, when can I get accommodations?"

Clerk: "There is one upper you can have four nights from to-night, but you had better speak quick if you want it."

Lady: "Is there no other way I can get to B?"

Clerk: "Yes. You can walk."

Had she been a man she would probably have "said a few things" to the clerk and would have gone some other way had that been possible.

Is it strange that the public has no love for corporations which employ such men to represent them? And what can you say to these and to other operating men when the president of the company, by giving out erroneous reports as to the condition of the company and by deferring the declaration of dividends, meanwhile buys up all the securities he can on the quiet and then suddenly announces that a dividend will be paid, thereby increasing the value of his holdings by millions of dollars?

Is it a wonder that when an accident case comes before a jury the corporation is universally "soaked"? Does not every case of this kind have its cumulative effect, and is it strange that so many people are "agin' the trusts"? Can we blame the yellow journals for their tirade against the high-handed outrages perpetrated by the big corporations, and should not everyone who believes in square dealing, whether owner, operator, or patron, speak up and condemn such practices?

The little knowledge which becomes a dangerous thing is one of the chief assets of the small public service corporation in its dealings with the people. The number of foolish things such a company can do is astonishing, and while few of them are wilful the effect upon the public is very much the same, and other companies throughout the country suffer on their account.

The company is charging, say, $100 per lamp per year to the city. Municipal ownership is talked and some "professor" is hired by the city as an "expert" to determine the cost to the city of making its own lights. The report shows that for $51.29, or some other absurdly low figure, the city can do this work, but nowhere in the report do we see any mention of depreciation, maintenance, insurance, loss of taxes, interest during construction, etc., etc.

The company in its fright immediately says, "Yes. We will take the contract for $55," thereby accepting the "expert's" figures and owning up to having overcharged the city for several years. The true facts in the case are that $100 was a just price ten years ago and that to-day $75 would be a fair price, one which is less than the city would be able to reach and upon which the company, in connection with its other business, could realize a small profit.

We might as well admit it—the public service corporation of to-day does not have the support from the public that it should, and the fault is largely that of the company itself. In these days, when municipal ownership is the talk of the town, the corporations should do all they can to curry public popularity and should show by their actions that they are better able to conduct such business than is the municipality.

Now to suggest a few points which need careful attention: A higher code of ethics of corporate management, good service, courteous treatment, fair rates, consideration of employees.

Much might be said upon the first subject, but it is a dangerous one upon which to get started. In these days of modern finance, there are many men, the writer regrets to say, who have become financially interested in public service corporations and who are in them strictly for what they can get out of them. To such as these the writer desires to quote some remarks made at a recent meeting of the National Bar Association:

"Once possible ostracism by professional brethren was sufficient to keep from serious error the practitioner with no fixed ideals of ethical conduct; but now the shyster, the barratrously inclined, the ambulance chaser, the member of the bar with a system of runners, pursue their nefarious methods with no check, save the rope of sand of moral suasion, so long as they stop short of actual fraud and violate no criminal law. * * * Never having realized or grasped that indefinable ethical something which is the soul and spirit of law and justice, they not only lower the morale within the profession, but they debase our high calling in the eyes of the public."

It is useless to try to make an impression upon the public unless the service is good,—that is what you are selling and the public wants to buy the best. Good service does not mean simply constant pressure on the lighting lines or regularity in the operation of cars. It includes, also, neatly painted poles, lines well kept up, good repavement of streets when underground construction is undertaken, clean cars, tidy employees, prompt response to trouble calls, etc., etc. The neglect of any one of these may make an enemy for the company, while the attention to such details is sure to make friends.

In its rule books, published for the guidance of its trainmen, one well-managed company instructs as follows:

"Employees shall bear in mind that they are engaged in a public service, in which they are constantly called upon to exercise great patience, forbearance and self-control. Politeness and courtesy continually practiced by employees will prevent controversy and complaint, and will greatly benefit the service.

"While the road is intended and expected to be a source of profit to the company, it is operated for the 'public convenience and necessity.' There should, therefore, be an earnest effort on the part of every employee to make the service so excellent and attractive that the public will always find it convenient and necessary."

If every individual in the employ of the public service corporation should live up to this rule, the millenium would be upon us at once and no one would have any occasion to complain of discourteous treatment.

Now, as to rates. Every company in the country will tell you that its rates are fair and equitable, but are they? Many of them are simply survivals of ancient days and are full of irregularities and unwarranted discriminations. Rates should not only be fair and just but should also be as simple as possible.

Step into a lighting company's office and ask the man at the desk for the price of electric current, and what do you get for a reply? Invariably, a lot of questions are "fired" at you; you never get a direct answer; you seldom even get a card with a printed schedule of rates.

It is not always wise to stick to a high schedule simply because you are allowed to do so by franchise or because the State board permits it. The public should get some of the advantages accruing on account of improvements in the art, and the company should at least appear to be generous by sharing its profit before it is forced to do so.

Does the company's duty towards its employees end on Saturday night when it turns over the envelope containing the week's wages? What is the *esprit de corps* in such a company?

Some companies supply pleasant lounging or club rooms, furnished with billiard tables, card tables, shower baths, and the like. Are not these attentions appreciated? The pension system for old employees costs but little and is one factor in keeping good men in the company's employ.

Most of your men are voters, and some of them have fathers and brothers who are also voters. They all have friends with whom they talk. If the company is broad-gauged and is liberal with its men, it soon has a small army talking for it and working for its interests; but if the company is close and "picayune" in its dealings with its employees, you may rest assured that it will not stand well with the community at large.

To be a success to-day, the public service corporation must, first of all, serve the public. It must put itself in a position where its acts cannot justly be criticised; it must educate the public in its ways of doing business; it must be liberal in its policy; it must not be afraid to state its case and to show that its business is being conducted honestly with a hope of a fair return upon its investment.

The Comparative Cost of Steam Engines, Steam Turbines and Gas Engines for Works Driving

SOME interesting data regarding the comparative cost of steam engines, steam turbines, and gas engines for generating electricity for light and power in a large plant, are given by W. Schömburg in a recent number of the "Elektrotechnische Zeitschrift." At present a number of independent steam engines are used.

The day load, assuming that half the machinery is at work at one time at its ordinary load, is taken as 900 KW., and the night load is about 250 KW. No spare plant is to be installed, as a small electric plant with battery is available in case of breakdown; but future extensions are to be allowed for.

Coal, at $4.50 a ton, delivered, and having a thermal value of 12,500 B. T. U. per pound, is obtainable, and also coke at $5.75 a ton and of 11,700 B. T. U., while the cost of water is 5.4 cents a thousand gallons.

Assuming that the future extensions amount to half the present power, and that the future night load will not exceed one-third of the future day load, it will be advantageous to install two 440-KW. machines rather than a single one of 900 KW. A third similar 440-KW. set can then be added later. Allowing for 300 working days in the year with 10-hour day shifts and 8-hour night shifts, the total units used will be as follows: —

K.W.H.

Day shifts, 440 × 2 × 10 × 300 = 2,640.000 ~~B. T. U.~~
Night shifts, 250 × 8 × 300 = ... 600,000 ~~B. T. U.~~

Total annual units..........3,240,000 ~~B. T. U.~~

The two generators will be approximately fully loaded during the day, while one alone will be run during the night, and will be only partly loaded.

RECIPROCATING STEAM ENGINES

The engines are assumed to be of the three-crank, triple-expansion type, running at 140 revolutions per minute, and working condensing with superheated steam at 180 pounds per square inch, and a temperature of 250 degrees to 275 degrees C. The steam consumption at full load, (allowing for the fact that the engines will not be running at quite full load constantly) is taken as 11½ pounds per I. H. P.-hour, which, with a generator efficiency of 92 per cent. and an engine efficiency of 88 per cent., making a combined efficiency of 81 per cent., gives 19¾ pounds per kilowatt-hour.

At night, working at about half load, the consumption will be about 22¼ pounds per kilowatt-hour. The total steam consumption at full load will thus be 17,700 pounds per hour, or, allowing for condensing machinery, feed pumps and pipe condensation, say, 21,000 pounds per hour. When the third machine is added, the consumption will rise to about 31,000 pounds per hour.

The condensers employed would be jet condensers, and the condensing water would be cooled in wooden cooling towers and used over and over again,—the maximum quantity to be circulated (when the third generating set is in use) being about 60,000 gallons per hour. The condensing machinery would be driven by a 50-H. P. single-cylinder engine, and the two feed pumps would also be steam driven.

Three water-tube boilers, with a heating surface of 2700 square feet each, would be required, and the boiler house would have room for a fourth. Each boiler would be fitted with its own superheater for about 85 degrees C. of superheat, but no economizer need be provided, as the feed-water could be warmed by means of the exhaust steam from the feed pumps. A 24-inch exhaust steam main would be required. The details of the cost of this installation are as follows:—

CAPITAL EXPENDITURE

(1) Two steam dynamos	$54,000
(2) Three water-tube boilers, with superheaters	15,000
(3) Condensing plant	11,500
(4) Feed pumps and oil separator.......	3,250
(5) Live and exhaust steam mains......	1,875
(6) Feed-water and cooling water piping	1,375
(7) Overhead hand-driven crane for about 10 tons and 40-foot span......	1,050
(8) Switchboard and connecting cables to dynamos	1.750
(9) Coverings for pipe troughs..........	750
(10) Spare parts for engines, etc.........	1,500
(11) Coal trucks, ash trucks, rails, weighing machine, etc.	2,750
(12) Engine room, 33 feet high and 3800 square-feet area	6,125
(13) 5200 square feet, boiler and pump house	6.600
(14) Foundations for the steam dynamos, etc.	3.625
(15) One chimney shaft, 160 feet high and 8 feet internal diameter at the top.	4.500
(16) Boiler brickwork	3.000
Total	$118,650

The capital cost per KW. installed is $\frac{23.730}{880}$ = $135,

or, allowing for the future extensions,

it is about................ $\frac{30.750}{1,320}$ = $117.50 per KW.

ANNUAL RUNNING EXPENSES

(1) Coal consumption:— 2,640.000 KW.-hours, at $\frac{19\frac{3}{4}}{7}$ pounds of coal per KW.-hour, and 600.000 KW.-hours, at $\frac{22\frac{1}{4}}{}$ pounds of coal per KW.-hour ....4.212 tons.

Heating-up (10 per cent.)............	423 "
Feed pumps and condensing plant...	425 "
	5,060 tons.
At $4.50 per ton......................	$22,520

(2) Lubrication and packing	$2,200
(3) Stoking, engine driving and supervision	6,250
(4) Water purification	225
(5) Upkeep and repairs:	
3 per cent. on items (1) to (6) of capital cost	2,610
2 per cent. on items (7) to (11) and item (16)	215
1 per cent. on items (12) to (15)	210
(6) Depreciation, 7 per cent., on items (1) to (19), (11) and (16)	6.740
Depreciation, 3 per cent., on items (10) and (12) to (15)	670
(7) Interest on capital at 4 per cent	4,745
Total	$46,635

Cost per KW.-hour therefore = 1.38 cents.

STEAM TURBINES

Two units of 440 KW. running at 2100 revolutions per minute (Parsons turbines) will be installed, and will require about two-thirds of the above engine room space. The steam consumption, allowing for the improved condensation required (about 90 per cent. vacuum), will be slightly higher than for the triple-expansion engines.

Each turbine will have its own condenser fitted close to it, and the condensing water cooler will have to deal with a maximum of about 115,000 gallons per hour. Upkeep and repairs will be about half as great as for the reciprocating engines. Lubrication will be greatly reduced and less attendance will be necessary, since in recent turbo-dynamos the commutation troubles have been successfully overcome. Comparatively light foundations will be required for the turbo-dynamos, but the boiler house equipment will remain practically unaltered.

CAPITAL EXPENDITURE

(1) Two turbo-dynamos	$35,000
(2) Three water-tube boilers, with superheaters	15,000
(3) Condensing plant	14,000
(4) Hot well and feed pumps	1,700
(5) Live and exhaust-steam mains	1,375
(6) Feed-water and cooling-water piping	1,250
(7) Overhead hand-driven crane for about 7½ tons and 36-foot span	850
(8) Switchboard and connecting cables to dynamos	1,625
(9) Coverings for pipe troughs	875
(10) Spare parts for turbines, etc	750
(11) Coal trucks, ash trucks, rails, weighing machine, etc	2,750
(12) Engine room, 23 feet high and 2350 square feet area	3,875
(13) 2350 square feet boiler house	3,025
(14) Foundations for the turbo-dynamos, excavations for the condensers, etc.	2 375
(15) Chimney shaft, 160 feet high and 8 feet internal diameter at the top	4,500
(16) Boiler brickwork	3,000
Total	$91,950

The capital cost per KW. installed is thus $104.50. All the prices include freight and erection.

ANNUAL RUNNING EXPENSES

(1) Coal consumption, including feed pumps, 10 per cent. for heating up and condensation loss = 5417 tons.	$24,375
(2) Lubrication and cleaning material	400
(3) Stoking, engine driving and supervision	5,625
(4) Upkeep and repairs:	
1½ per cent. on item (1) of capital cost	525
3 per cent. on items (2) to (6)	1,460
2 per cent. on items (7) to (9), (11) and (16)	160
1 per cent. on items (12) to (15)	140
(5) Depreciation, 7 per cent. on items (1) to (9) and (11) and (16)	5,420
3 per cent on items (12) to (15)	415
(6) Interest on capital at 4 per cent	3,680
Total	$42,220

Cost per KW.-hour therefore = 1.25 cents.

GAS ENGINES

Two gas engine dynamos for 440-KW. each will be required, and these would preferably be of the 4-cycle, double-acting type with tandem arrangement of cylinders, though single cylinder engines could be used. The speed would be 130 revolutions per minute. Starting would be effected by compressed air provided by a small electric pump and air cylinder. The necessary cooling water would amount to about 9 gallons per horse-power-hour, so that cooling arrangements for dealing with a maximum of 20,000 gallons per hour (when three generators are in use) must be installed, and this amount of water must be cooled from about 40 degrees C. to 25 degrees or 28 degrees C.

Three power gas generators would be erected (one as a spare) with the necessary steam raising plant, purifiers, etc. Each generator should be amply large enough for 600 H. P., and with an efficiency of 75 to 80 per cent. each generator would require about 7800 pounds of coke per day of 10 hours. Consumption tests on engines of this size were not available, but taking the guarantee figures of well-known makers, the consumption of coke should not exceed 1.65 pounds per kilowatt-hour at full load, or 2.45 pounds per kilowatt-hour at half load.

To allow for the losses in banking one gas generator during the night, an addition of 10 per cent. of the full load consumption must be made. The lubrication expenditure will be somewhat greater than for the triple-expansion steam engines, whilst the attendance expenses will be less, owing to the absence of condensing plant. The foundations will, however, have to be more substantial.

CAPITAL EXPENDITURE

(1) Two gas dynamos for 440 KW. each.	$56,250
(2) Three gas generators with purifiers, steamers, electric blowers, piping and valves	6,750
(3) Compressed-air plant for starting	1,550
(4) Cooling water plant with electric centrifugal pump, iron cooling tower and piping	3,625
(5) Overhead hand-worked crane for 10 tons and 53-foot span	1,375
(6) Gas and air piping, exhaust chambers and valves for the engines	1,375
(7) Switchboard and cables from the dynamos	1,875
(8) Coverings for pipe troughs	1,450
(9) Spare parts for the engines and dynamos	2,250
(10) Weighing machine, rails, coke hoist, coke trucks, etc.	4,000
(11) Engine room, 30 feet high, and 5400-square foot area	8,750
(12) Gas generator room, 3600-square foot area	4,550
(13) Foundations and pipe troughing	5,500
Total	$98,300

The capital cost per KW. installed is therefore $112.50.

ANNUAL RUNNING EXPENSE

(1) 2,640,000 KW.-hours, at 1.65 pounds of coke per KW.-hour, and 600,000 KW.-hours, at 2.45 pounds per KW.-hour + 10 per cent. loss in gas generator = 2810 tons of coke, at $5.75 per ton	$16,160
(2) Lubrication and cleaning material	2,625
(3) Attendance and supervision	5,500
(4) Water for the purifiers (12,000,000 gallons per year, at 5.4 cents per 1000 gallons)	675
(5) Upkeep and repairs:	
3 per cent. on items (1) and (2) of capital expenditure	1,890
2 per cent on items (3) to (8) and (10) expenditure	305
1 per cent. on items (11) to (13), expenditure	190
(6) Depreciation, 7 per cent. on items (1) to (8) and (10)	5,480
3 per cent. on items (11) to (13)	560
(7) Interest on capital expenditure at 4 per cent.	3,970
Total	$37[illegible].355

The cost per KW.-hour is therefore 1.1[illegible] cents.

The above figures show that in this case the steam turbines lead to the lowest capital cost, but that the gas engines give a lower annual cost. The writer points out, however, that no general rule can be laid down, since the price of fuel, the overloads to which the plant is subjected, the value of floor space and other similar variables enter into the question and make it necessary to consider each case in detail in the way outlined above.

A New Source of Rubber

REPORTS come from Mexico to the effect that there is an active development of guayule rubber properties. For many years guayule was known to contain rubber, but it is only within a short time that a process has been invented for the extraction of the gum for commercial use.

Although the product was of an inferior quality and of little value, it was enough to set chemists and inventors to work on the problem. However, none of the methods have yet attained a degree of perfection, as the known results vary from 10 to 12 per cent., whereas the quantity of gum contained in the shrub is known to be approximately 18 per cent. A sample lot of excellent quality, extracted with a process in the experimental stage and not yet patented, brought between $1 and $1.25 per pound.

No claim is made that the gum extracted from the guayule will ever take the place of rubber, but it can be made a substitute in many forms of manufacture. This industry has now passed from the experimental to the practical stage, and is destined to become a very important one in Northern Mexico, especially in the State of Coahuila. Factories which are already working, and those now under construction within a small radius of Saltillo, will represent an outlay of thousands of dollars.

Costs of and Results from Soliciting and Advertising

By H. K. MOHR

A Paper Read at the Recent Convention of the Association of Edison Illuminating Companies

FROM a report read before the convention of the National Electric Light Association, held last June, the following extract is quoted:—

"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. * * * The gaze and the study of the manager (of central stations) 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. * * * Beyond this, numerous plants scattered all over the country, illy 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. * * * It may be asserted without the slightest fear of contradiction that the industry has been revivified by the 'publicity' campaigns of recent date, that it has ceased to minister to the comfort of the many in order to meet the necessities of the millions, and that it has made splendid advances towards the accomplishment of its universal purpose and potentialities."

To what extent has the "inward gaze" of the central station manager been directed toward the commercial side of the business and to what purpose? Has there not been a curious lack of system in a concerted effort on the part of the lighting companies to develop their business-getting departments? At the very least, has there not been a surprising lack of intelligent co-operation?

Take the engineering side of the central station business as an example. From the very start there has been a striving for uniformity, a constant study of existing as well as problematical conditions. This study has not been individual; the knowledge of one is open to all; the experiences and difficulties and methods of solution are common property. If electrical engineering had been secretive it would never have been safe or sane.

The result has been that to-day engineering problems of the central station are worked out on certain fixed principles based on experience and common sense. In the event of electrical or mechanical trouble either inside or outside of the station there is no confusion of method in correction: there are not four or five right ways of making repairs, and the wrong ways are definitely indicated. The same thing is true in new construction in but slightly less degree.

How far would the central station business have progressed if every engineer did things in his own way,—if good engineering practice was a negligible quantity? Imagine the confusion of methods, the uncertainty of service, the expense of apparatus, the prohibitive cost of current.

Central station engineering is not the title of this report, but a comparison of methods and development with the commercial side of the business serves a purpose.

Are there any certain laws for getting new business and retaining old? Are there any fixed rules, to which anyone may refer, that govern the making of rates, the cost of a soliciting department, the expense of advertising, the salary of the solicitor or his qualifications, the warrantable financing of a customer's installation, or the thousand and one problems, serious problems, with which the central station manager must contend daily?

Is it not true that every company in this association does all these things in its own way? Is there such a thing as uniform policy in the matter of making investment to secure new business? Are there any fixed rules in existence, outside of the use of common sense, to which the manager can turn in case of emergency or difficulty? Does not every company employ individual methods,—not to say anything about individual rates? Is there not a tendency to find out all you can about the other fellow and tell him as little as possible about yourself?

In this era of municipal ownership agitation, the public utility company's most vulnerable point is the lack of uniformity in rates and selling methods existing throughout the country. Every company whose interests are jeopardized finds itself immediately upon the defensive with regard to the principal point of attack, and, even if able to clear its own skirts of unfair methods, must perforce, directly or indirectly, call attention to the delinquencies of its sister companies.

Is it possible to evolve from the many and varied methods employed by the member companies in their business-getting departments certain standard methods of procedure under similar conditions, and, if it is possible, is not such a consummation most desirable?

There are those who will at once claim that the great difference in the selling conditions existing in the various cities makes it impossible and undesirable to reduce the selling of electricity to an exact science, as is electrical engineering. There is a difference, however, between an exact science and general rules, and, after all, if the latter could be established a great step forward would have been taken.

Human nature is the same in San Francisco as it is in New York, although its expression may vary somewhat; that statement is also true of human capabilities. Why is it not possible, therefore, with the wide and long experience of the older companies, to determine very closely what inducements are necessary to tempt an individual to purchase our commodities, how far it is necessary to go in rates and the financing of

MAILING FOLDERS THAT WERE BUSINESS-GETTERS

1 and 9. Edison Electric Illuminating Company of Boston. 2. Edison Electric Illuminating Company of Brooklyn. 3. Chicago Edison Company. 4. St. Paul Gas Light Company. 5. Potomac Electric Power Company. 6. New York Edison Company. 7, 8 and 10. The Philadelphia Electric Company.

first cost to obtain new business? How much advertising is necessary and at what cost? What salary is necessary for a competent electricity salesman? What is a standard method for determining his efficiency and increasing it, and so on through the entire selling problem?

In compiling a report on this subject the endeavour has been to get away, as far as possible, from an expression of personal opinion, and to ascertain the facts in connection with the cost and efficiency of soliciting and advertising as demonstrated by the methods in vogue and results obtained by the member companies, the subject of rates being excluded.

To this end, thirty-one questions were framed, eighteen on soliciting and thirteen on advertising, covering the subject broadly. These questions were printed upon sheets for convenient reply and mailed to every company in the association. It was realized that certain questions, particularly some of those on advertising, would not receive many answers, due to the fact that some of the companies are not advertising systematically, but it was the hope and expectation that more of the companies would have given full and frank replies than has actually been the case.

For convenience of reference, the questions submitted are herewith reprinted.

SOLICITING

1. Gross revenue per year, of your company, for light and power for commercial business, exclusive of municipal business and merchandise sales.

2. Average cost of soliciting for past three years, charging to this account all expenses for securing new business, except advertising.

3. State number of contracts closed and 16-candle-power equivalent, 1905, as compared with 1904, these figures to be exclusive of increase of installation of old customers.

4. Give number of solicitors employed at present and average number during the year 1905. State number whose work is wholly soliciting and the number of solicitors who have mixed duties.

5. What is the average salary of your solicitors per year (not including heads of departments)?

6. State methods of payment of solicitors, whether salary or commission, or both; and on what basis do you pay commission? If you have changed from one system to the other what has been the result?

7. Do you allow premiums of any kind for successful work and on what basis?

8. State the average number of contracts secured per solicitor per year. (This refers to solicitors only; do not include heads of departments.)

9. State the average amount of new business secured per year per solicitor in 16-candle-power equivalent. (This refers to business secured by solicitors only; do not include heads of departments.)

10. Into how many branches is your soliciting department divided? Name them, prescribing the duties or limitations of each branch.

11. Do you allow commissions to architects, engineers, builders, wiring or motor contracts, and on what basis? If so, does it aid you in securing new business, and to what extent?

12. Do you divide your territory, giving a stated section to each solicitor, or do you permit each to extend his work in whichever direction he can secure contracts?

13. Describe your follow-up system for checking solicitors' work.

14. How often do your solicitors meet for general conference, and how freely may they discuss existing conditions at such conferences?

15. State how many inhabitants there are in your city for each solicitor employed. Answer this by dividing your population by the total number of your employees who do the work of soliciting.

16. What was your percentage during 1905 of business connected to business removed from your circuits? In other words, for every 100 16-candle-power equivalent connected to the system, how many 16-candle-power equivalents were lost?

17. Do you employ women for soliciting in the residence district? If so, are they successful, and why?

18. What general or specific rules do you follow in the matter of making investments for installation incident to getting new business? Please divide your answers as follows, stating method in each case:—

a Do you make free sign installations?

b Do you make free motor installations or do you make use of a loan proposition?

c Would you make the investment necessary to change an elevator from hydraulic to electric?

d Do you do any wiring free of charge (residences or stores)? Do you supply first installation and free renewals of special amps, such as the high efficiency and Nernst lamps?

e In shutting down isolated plants, do you aid in financing the electric installation, and how?

ADVERTISING

1. What did you spend on advertising during the past year, excluding the cost of your bulletin, if you publish one?

2. State the cost of each sub-division of your advertising account, such as newspapers, follow-up advertising, street car advertising, miscellaneous.

3. State the total number of direct replies received to advertising for one year.

4. State the number of contracts closed during the year 1905 by following up actual replies received. Exclude all contracts closed with parties whose names are on your mailing lists, but who made no direct replies to advertising sent out.

5. Using the number of contracts closed as per Question 4, state the 16-candle-power equivalent of this business and the estimated yearly value of the same.

6. How do you check up the results of newspaper advertising? Do you look upon newspaper advertising for the central station as a measure of policy or as furnishing a direct return, or do you think it is partially one and partially the other?

7. What in your opinion is the best method of advertising for the central station with a limited appropriation; in other words, if an appropriation of from $5000 to $15,000 were made, would you spend it in newspaper, follow-up, or street car advertising, and why?

8. How much per capita of population in your territory did you spend on advertising during 1905? (Include all advertising expenses.)

9. In a follow-up system, which do you consider the better policy,—frequent communications of average workmanship as to printing, design, etc., or fewer communications of higher grade? How often each month or year would you circularize a given list?

10. What did your bulletin cost you during the year 1905?

11. How did you compile your mailing lists, and what method do you pursue in keeping them up to date?

12. Give whatever data you have showing the advertising value of electric signs.

LIGHT AND POWER BOOKLETS

1 and 3. The Philadelphia Electric Company. 2. Chicago Edison Company. 4. Edison Electric Illuminating Company of Boston. 5. Edison Electric Illuminating Company of Brooklyn. 6. Potomac Electric Power Company. 7. New York Edison Company.

SOME EXAMPLES OF EFFECTIVE BULLETIN COVERS

13. Send a copy of what you consider the most efficient advertisement you have ever issued, judged by actual replies or sales resulting from the same. Also a copy of the best newspaper advertisement; the best mailing card; the best circular letter; the best booklet, judged by the same standard; with percentage of replies received to pieces mailed (if the latter is possible). Also send a copy of your most effective bulletin cover.

SOLICITING—COST OF SOLICITING

Questions 1, 2, 4, 5 and 15 deal directly with the cost of soliciting. They were framed with the thought that the answers would indicate a more or less definite method of determining how much money should be spent in order to get business in proportion to the revenue of any one company or the population of the territory covered, etc.

The gross revenue, exclusive of municipal business, was asked for, inasmuch as the latter is obtained, as a rule, without the aid of the soliciting department. An analysis of the replies obtained discloses the fact that the cost of soliciting for all companies approximates 1 per cent. of the gross revenue. That figure seems to hold, with two exceptions, in all companies whose gross revenue is under $1,000,000 per annum.

The cost of soliciting for companies whose gross revenue falls between one million and two and one-half millions falls below 1 per cent. and then takes a jump to $1\frac{3}{4}$ per cent. for the companies that have a gross revenue of three million dollars and over.

If allowances are made, therefore, for the element of difference in bookkeeping, the figure of 1 per cent. of gross revenue, exclusive of municipal business, as applied to the expense of a business-getting department, would seem to be the accepted annual cost among central stations. It may, or may not, however, be significant that as a company approaches the two-million-dollar class it seems to reduce its proportionate expenditure with a proportionate reduction in business-getting results as shown by the per cent. increase in new business. When a company breaks into the three-million-dollar class, however, there appears to be a sudden awakening to the fact that liberal expenditure is required if largely increased revenue is an object, and here we see the cost of the business-getting department almost doubled.

Would these facts tend to prove that the cost of an efficient business-getting department should approximate 2 per cent. rather than 1 per cent. of the gross revenue per annum? If it has proved a wise expenditure for the three-million-dollar company, why not for the half-million-dollar company?

Questions 4 and 15 were asked with the idea that there might be some reasonable indication of how many solicitors would be required to cover a given field, worked out on the population basis. The result was unsatisfactory, the population per solicitor varying from 10,000 to 75,000. Twenty-five thousand of population per solicitor seems to be an average figure for the smaller companies, although we find one $500,000 company that employs no solicitor at all. In the larger cities there is a great divergence in these figures, although it should be noted that among the five largest cities the companies who show the greatest connected load per capita have the smallest number of people per solicitor, showing that it pays to cover your field thoroughly.

There appears to be considerable unanimity among the member companies as to the proper average salary of a solicitor, the figure of $900 per annum being that which appears most frequently. The business of selling electricity requires expert salesmanship. It frequently requires a certain technical knowledge. The public as a whole knows little about electrical terms or costs. They can be interested and finally convinced only by salesmen who understand their subject fully and talk of it enthusiastically; above all, they resent the sending of a boy to do a man's work.

Can you get any more than an average man for an average salary of $75 per month? You certainly cannot get an expert salesman!

Straight salary without premiums is the almost universal method of paying a solicitor, but it is safe to say that the majority of central station managers would like to be convinced of the efficacy of a commission in increasing a solicitor's initiative.

The average solicitor working for a stated salary is prone to fix a certain number of contracts closed monthly as a standard. If he approximates that standard he is content, or nearly so. Would not a commission in addition to his salary (based on lamp equivalent contracted for and connected) on all lamps over a certain determined number per month provide the necessary fillip to his jaded soliciting consciousness?

Three companies who answered this question pursue a combination salary and commission method of paying solicitors. One answer is as follows:—

"Each solicitor is allotted a certain number of 16-candle-power equivalent to obtain each year, and a commission is paid on all above 80 per cent. of this amount on a basis of 50 cents for each customer obtained and 1 cent per each 16-candle-power equivalent. About eighteen months ago we changed to this basis with good results, the majority of the solicitors obtaining considerably more business since that time. This year we have changed from the yearly basis of paying commission to the monthly basis, with the result that a solicitor who before did not obtain a commission, is now receiving a commission every month."

It would be exceedingly interesting and instructive if the representatives of those three companies would give us the benefit of their experience in this matter, with a little further information as to the details involved.

METHODS OF HANDLING THE SOLICITOR

Questions 6, 7, 10, 12 and 14 were asked for the purpose of bringing out the various methods of handling the solicitor and developing his capabilities and resources.

The answers to Questions 10 and 12 brought out nothing that is new. The smaller companies who do not employ more than five to eight salesmen do not sub-divide the work of the soliciting department. The general rule seems to be to allow them to get business of any nature when and how they can. As the companies develop, however, there is a tendency,—necessity is probably a better word,—to break up the soliciting department into distinct branches. This phase reaches its highest development in the business-getting organization of the largest five or six companies, and here we find that tendency towards specializing which is present to a large degree in almost all manufacturing operations of magnitude.

A composite organization of the soliciting department of the large companies would be approximately as follows:—

- General Manager..
  - Contract Agent...........
    - 1—District Manager......
      - Solicitors for general illumination and power up to 10 H. P.
    - 2—Electric Sign Department.
    - 3—Exhibition Department.
    - 4—Power Department....
      - Isolated plants,
      - New construction,
      - Refrigeration, etc.
  - Adv. Manager.

The popular method of keeping track of the solicitors' work is through the medium of the daily report, either directly to the contract agent, or, in some cases, to the district manager,—some of the companies have the solicitors make daily written reports of visits made, including date and result of each visit. These reports are forwarded daily to a record clerk at the main office for file and follow up.

Probably the newest feature of the business-getting department of a central station is the monthly solicitors' meeting held by a few of the companies. These meetings are not unlike training schools. They are presided over by the contract agent, and papers are prepared in advance and read each month by the engineers, district managers, and other employees.

These papers are on a variety of subjects germane to the business-getting department and perforce of interest to the solicitor. After the papers are read a general discussion follows, in which all employees present are expected to take part. These meetings are, in effect, miniature Edison conventions, and should at least tend to increase the efficiency of a solicitor.

THE RESULTS OF SOLICITING

How may we properly gauge the results of soliciting, the efficiency of a soliciting department and the individual solicitor? Questions Nos. 3, 8 and 9 were intended to bring out answers which would throw some light upon this subject. The result has been bewildering.

There are those who will at once say it is impossible to judge a solicitor's work in New York by comparing it with the work of a solicitor in a town of 50,000 inhabitants, and that the temperament and requirements of people living in different sections of the country vary so greatly that a comparison such as this would be worthless.

The question is debatable. If allowances are made for varying conditions it may be possible to agree upon some middle ground, some approximate standard. It does not seem reasonable that such a great variation should exist between companies operating in cities of approximately the same class, as is shown by the answers received to the above questions.

If we except the solicitor who is engaged upon special work, isolated plant investigation and follow-up, for example, is it possible to agree upon a reasonable number of contracts which the general solicitor may be expected to secure in a year's time?

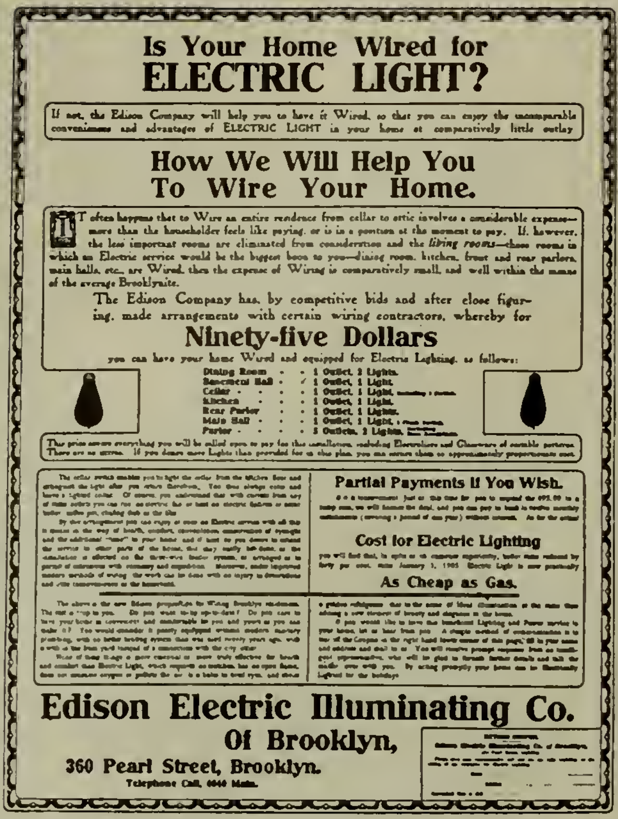
The average number of contracts secured per solicitor for different member companies in all sections varied from 110 to 494 per annum, but that fact does not prove that comparison is impossible, for the above-mentioned averages applied to two cities of the same class!

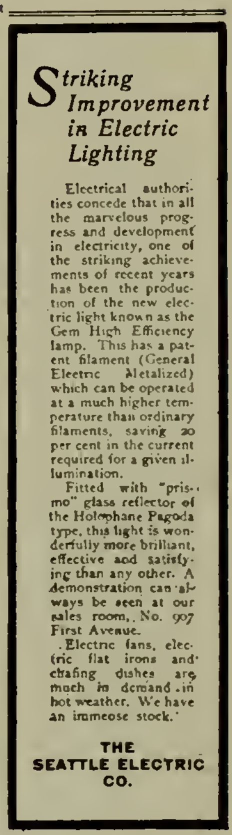
The average number of contracts secured per solicitor per year for all companies who replied to this question was 240. This is not an average of an average, but is the total number of contracts for all companies divided by the total number of solicitors.

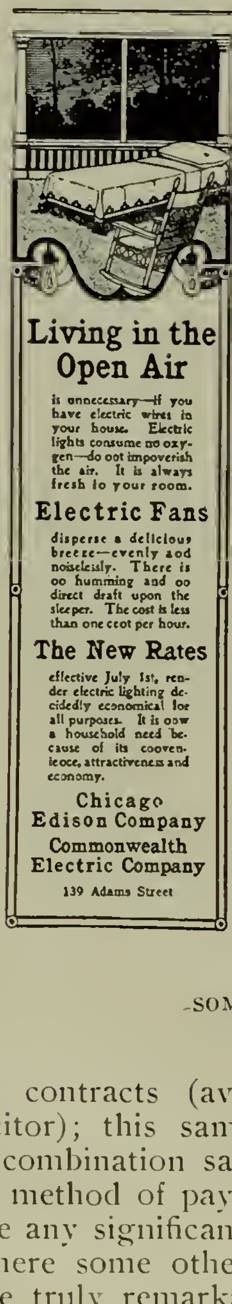
The smaller companies averaged up to this figure very well; in fact, the majority of them ran above it. It would, therefore, seem that a company located in a city of the first class without competition should find food for reflection, if its figures fall below the average mentioned.

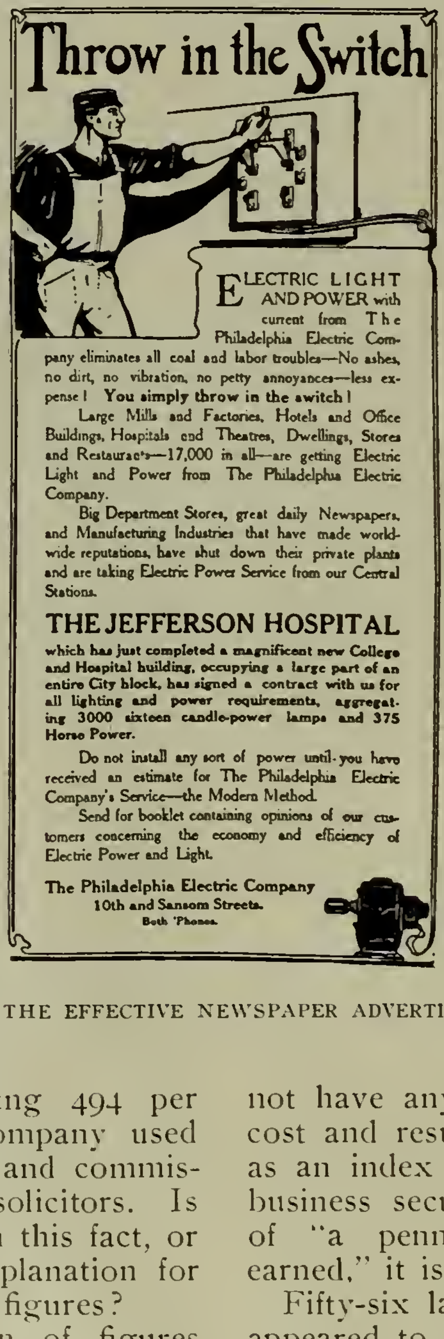
The average number of contracts secured per solicitor may be affected by the fact that one company will have a greater number of solicitors in proportion to the number of prospects than another, and there are, no doubt, other qualifying circumstances; but this data may be an entering wedge, or may at least suggest other methods of arriving at some conclusion in this matter.

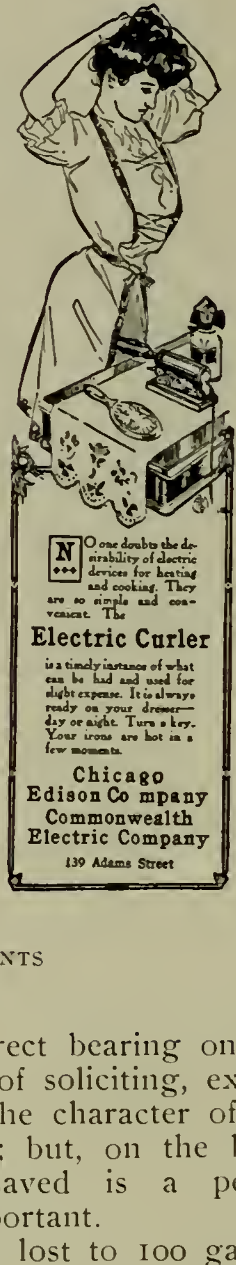
One of the member companies during the year 1905 secured 20,000











SOME OF THE EFFECTIVE NEWSPAPER ADVERTISEMENTS

new contracts (averaging 494 per solicitor); this same company used the combination salary and commission method of paying solicitors. Is there any significance in this fact, or is there some other explanation for these truly remarkable figures?

A yearly compilation of figures bearing upon soliciting results, with the sincere co-operation of the member companies, should prove of practical value to the central station manager.

Proportion of lamps disconnected to lamps connected each year may not have any direct bearing on the cost and results of soliciting, except as an index of the character of the business secured; but, on the basis of "a penny saved is a penny earned," it is important.

Fifty-six lamps lost to 100 gained appeared to be the highest figure in the answers received to Question 16, varying from that number to 20 lost to 100 gained as a minimum. An analysis of the answers received would seem to show 43 lamps lost to 100 gained as an average, with 40 to 100 as a figure to be striven for.

WARRANTABLE INVESTMENT TO SECURE NEW BUSINESS

It would be entirely impossible to do justice to this subject within the confines of a report. There is, perhaps, a greater divergence of opinion and treatment of this matter among central station managers than any other problem which they have to face. And nowadays the condition is met almost daily of gaining business or losing it by either making investment or refusing to do so.

The policy of making free sign installations seems to be generally accepted as good practice. Free signs have proved big money earners wherever tried, and there seems to be no difference of opinion on this point. A number of the member companies, however, in the face of these results, do not as yet take advantage of this opportunity for advertisement and increased income.

A reasonable method of making free sign installations, in use by one of the member companies, is by a term contract of two or three years, with a monthly guarantee (depending upon the number of lamps and cost of sign), the sign and wiring remaining the property of the company.

Very few of the companies make free motor installations. One company sells the motors at cost; another makes a free trial loan of 30 or 60 days, the motor to be paid for at the end of that time if satisfactory; a third rents motors "on occasion at so much per month." There is apparently no well tried out method.

None of the companies makes the investment necessary to change an elevator from steam-hydraulic to electric-hydraulic.

The matter of free wiring is handled in a variety of ways. Many companies do no free wiring of any description; some do free wiring for outside arc lamps only; others do free wiring for incandescent window lighting, and, when policy demands it, in order to retain old business. One company does free wiring if the prospective customer is of the long-burning variety; in practically all cases the same company pays for the wiring in free current. For example, if a man makes an expenditure of $100 in wiring, the company allows him to use $100 worth of current at regular rates without charge.

In shutting down isolated plants and substituting central station service, the larger companies furnish the bulk of experience. There is a disposition to aid in financing this change by the purchase of the steam machinery at second-hand valuation.

Where the size of the prospective business demands it, the old plant is purchased at a high valuation, the company so doing taking a chance of losing a little on re-sale; necessary wiring is sometimes done free of charge, where it is necessary, in order to connect the business to the company's circuits. There is no fixed rule apparently in handling such cases; each company does what it has to in order to secure the business, the amount of investment by the company depending upon the shrewdness or demands of the prospect.

It ought to be possible, by discussion and free exchange of experience, to determine what is legitimate and what is illegitimate investment in order to secure new business, and also to agree upon a more or less certain method of handling the individual cases arising where investment is necessary.

The North American
AND
The Philadelphia Electric Company

The huge 21-story North American Building and the great plant of The North American newspaper will hereafter receive current for all lighting and power requirements from The Philadelphia Electric Company.

The fact that a great private power plant of modern construction, operated by skilled engineers, is admittedly more expensive and less efficient than Philadelphia Electric service proves conclusively that the installation of a private plant at the present time is an economic error.

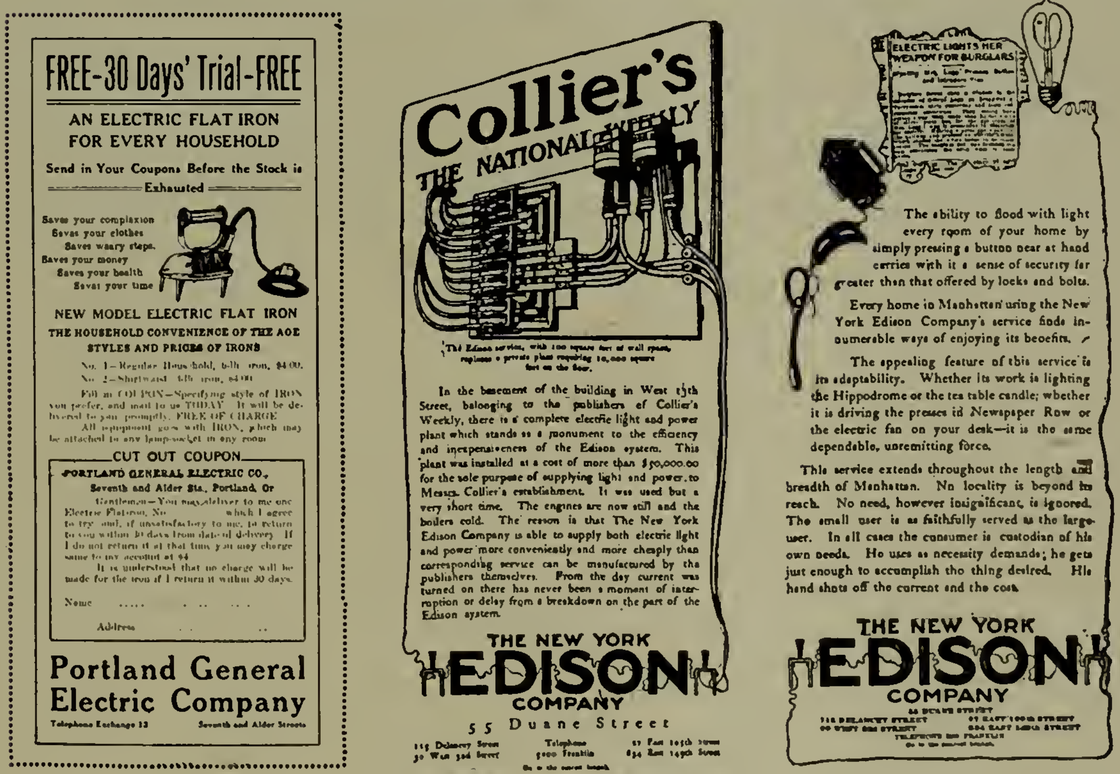
4000 ELECTRIC LAMPS AND
500 HORSEPOWER IN MOTORS

are used to light the office building and operate the great sextuple Hoe presses, stereotyping plant, linotype machines, refrigerating apparatus, hoists, exhaust fans, pumps, etc.

Five of Philadelphia's great daily newspapers have now ceased to operate their own power plants, and are furnished electric light and power by The Philadelphia Electric Company. Great plants in every section of the city are being superseded by Central Station Service—the modern method.

Tests, estimates, rates—free of charge. Write or telephone to the Commercial Department, 10th and Sansom Streets.

Electricity Everywhere for Everything in Philadelphia



MORE NEWSPAPER ADVERTISEMENTS EFFECTIVE IN GETTING BUSINESS

ADVERTISING

Starting with the premise that advertising is not only a good thing, but also an essential adjunct to the business-getting department of a central station, how may we determine the proper expenditure and the reasonable results to be expected therefrom?

There is such a paucity of reliable information upon this subject, as evinced by the incomplete replies received to the questions asked, that it is extremely difficult to arrive at any definite conclusions. Only four member companies turned in a complete set of answers; quite a number of the companies answered in part; some kept no records, and others did no advertising at all.

Questions 1, 2, 8 and 10 of the advertising section are concerned directly with the cost of advertising, with a view of determining the amount of an appropriation in comparison with the gross revenue* of any one company.

Advertising costs of the member companies varied from one-quarter of 1 per cent. to $2\frac{1}{2}$ per cent. of the gross revenue, the average figure being $1\frac{1}{4}$ per cent. One of the smallest companies furnished the highest figure of $2\frac{1}{2}$ per cent., and the average expenditure of the larger companies was close to $1\frac{3}{4}$ per cent. of the gross. It would seem, therefore, that the companies who do advertising in the most systematic manner are very closely approximating the figure of 2 per cent. of the gross revenue mentioned some time ago.

A central station about to start a systematic advertising campaign and not knowing how much to appropriate for the purpose might determine on 2 per cent. of the gross revenue as a very good figure, judging from the experience of the other member companies, but to state that 2 per cent. is the proper amount for all companies might be misleading and contrary to fact. One of the best-known men in the advertising world covered the question of advertising appropriation as follows:—

"How much can be judiciously spent for advertising depends largely on the possibilities of the business. If the field is such that the business can be increased indefinitely, the amount of money that can be judiciously paid for advertising is only limited by the ability to pay. Where the field is limited and only a certain amount of business can be developed anyway, the advertising appropriation should be governed accordingly."

Having obtained an appropriation for advertising, how may the money be spent to the best advantage? Questions 6, 7, 9, 11 and 12 were framed to bring out the experience

* Gross revenue, as per question 1, soliciting section.

and judgment of the various member companies upon this subject. An analysis of the answers received shows a considerable unanimity in thought regarding the most efficient method of expenditure, and a composite opinion upon the handling of a given appropriation would be approximately as follows:—

Spend three-fifths of the appropriation upon a follow-up campaign of direct mail advertising.

Spend one-fifth of the appropriation upon newspaper advertising and street-car advertising.

Spend one-fifth of the appropriation upon miscellaneous advertising, including bulletin, stuffers for bills, and the like.

There is a distinct feeling that a series of novelty mailing cards, facsimile typewritten letters, booklets, etc., judiciously interspersed and mailed to carefully compiled lists, is far and away the most efficient and resultful kind of advertising for the central station. There are several reasons for this, one of them being the nature of the commodity we have to sell and its necessary appeal to distinct classes.

Power users are a distinct class; so are users of electric signs; so are users of electric light, although in less degree; the percentage of people also who cannot afford to wire their dwellings for electricity is considerable.

It follows, therefore, that the large percentage of waste circulation inevitable in newspaper advertising reaches its maximum in the case of the central station. Added to this is the difficulty of telling the electrical story properly and fully in the advertising columns of the newspaper without utilizing more space, at greater expense, than would be commensurate with results obtained.

The function of newspaper advertising for the central station appears to be threefold, namely, educational, supplementary, and as a measure of policy. As an educational factor, in letting the public at large know what you are doing, in creating an interest, and, if possible, a pride in your organization as a municipal institution, it is valuable; in supplementing and emphasizing your follow-up-campaign it has its uses; from the standpoint of "good policy" it may mean a whole lot or nothing.

The money spent upon the bulletin seems to meet universal approval; the results, from an educational standpoint, are invaluable, and the uses which it may be made to serve are only partially realized. Stuffers of varied description, accompanying the bills, and even printed matter upon the bills themselves, bearing upon matters electrical, unquestionably serve a good purpose.

Nothing is more important than the proper compilation of a mailing list, and it is one of the most difficult problems the advertising man is obliged to face. The favourite and apparently the best method of making up this list is to have the solicitors thoroughly canvass their districts and send in the names of the most likely prospects contained therein. The value of such a list, however, depends entirely upon the sincerity of the solicitor, and the thoroughness with which he goes about his work.

In addition to the names furnished by the solicitors, the list should be filled out with names obtained from such publications as the Stationary Engineers' Directory, the Blue Book, and city directory. It should also contain the names of architects and builders and engineers and the names of prominent men in the municipality.

The data regarding the value of electric signs erected by the central stations for their own advertising purposes are not sufficiently specific to be of value.

ADVERTISING RESULTS

If advertising is worth anything, it should certainly be worth while to keep a record of the traceable results; and yet only three companies kept records of replies received to advertisements and contracts closed as a result therefrom. There are, of course, indirect results and benefits from advertising which it is impossible to measure, but the direct reply to an advertisement, with its attendant follow-up by a solicitor and the eventual signing of a contract, should certainly be a matter of record. The simplest kind of a card index would fulfill every requirement for reference, and an office boy would have sufficient ability to take care of it.

Executive officers are apt to demand tangible results for moneys spent upon physical betterments or for an increase in the salary list, and there is no good reason why they should not demand the same thing from an advertising department, which is spending several per cent. of the company's gross revenue each year.

If all of the companies kept such records, it would be possible to judge of the relative efficiency of the advertising issued, and possibly to determine upon an average cost per inquiry, as well as a maximum cost, which latter figure, if exceeded, would be sufficient warrant for an organization to either change its advertising policy or seek reasons for the excessive expense.

So few companies keep track of advertising results that it serves no very good purpose to review the figures; as a matter of record, however, costs per inquiry received (considering follow-up costs only) varied from $2 to $25, and in return for expenditures during 1905, varying from $6500 to $27,000, the estimated yearly value of contracts obtained as a direct result of "follow-up" advertising varied from three-fourths of the investment to seven times the investment, proportionate results sufficiently wide apart to be worthy of comment.

The percentage of contracts eventually closed as a result of replies received to advertising compared to the total number of replies received varied from 8 per cent., the lowest figure, to 13 per cent., the highest, which figures may have some bearing upon the efficiency of the respective soliciting departments.

CONCLUSION

The conclusions reached as set forth in this report are based upon the data placed at our disposal. Changes or modifications may result from the study of more exhaustive information regarding the subject.

From the inception of the electrical industry special care and attention have been given to the keeping 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 inward, and the interest shifted from engineering to commercial problems," may we not hope for a committee to help us overcome our rapidly increasing difficulties?

Business-Getting Methods in Denver

By FRANK C. FARRAR, of the Denver Gas and Electric Company

A GROUP OF SERVICE SUPERVISORS AND YOUNG WOMEN INSPECTORS OF THE DENVER GAS & ELECTRIC COMPANY, OF DENVER, COL.

EXPERIENCE of a number of years has perfected the system of development of new business of the Denver Gas & Electric Company to such an extent that it has become almost a science. Paradoxical as it may seem, each step forward has served to demonstrate more and more positively that the possibilities in both the gas and electric fields are increasing rather than diminishing as the business grows.

Increasing returns in revenue have themselves become the means of bringing to the company additional income. In other words, the properly built and properly lighted sign, bought and paid for by the user, has shown wonderful advertising and soliciting qualities for the company.

Verily, in Denver business has bred business.

This may be somewhat an ideal condition. Undoubtedly it would be an impossibility if the company did not pursue with ever-increasing vigor its policy of aggressive business getting, carried on by the best talent that can be obtained. On this point it is the policy of the company to be exceedingly liberal. There is no hesitancy in employing a man who can obtain results. And the policy is equally advanced in adopting any system or method that means results.

So thoroughly has the spirit of business-getting permeated the working forces of the company that practically every man—and woman, too—connected with the company takes a hand in bringing in additional revenue. This is due, of course, to the policy of the management in giving full recognition to ability and effort.

At present the business-getting force—that is, the active soliciting force—consists of fourteen representatives, fourteen assistants, two special power men, one special display lighting man, one special industrial gas man, one man who devotes his time to new buildings, seven men known as "service supervisors," who give their time to present consumers, and seven young women inspectors who visit present consumers.

Briefly, the system of carrying on business is as follows: Each representative has charge of a district that includes a portion of the business section and a portion of the residence section. Generally he takes care of the business district and supervises the residence district, the active work here being done by his assistant. The special men all work at large, usually in company with the representative in whose territory they may be working. The mission of the service supervisor, and of the young woman inspector, is to visit all consumers. In behalf of the consumer they see that appliances are in the best of condition and giving satisfaction in every respect. As a return to the company they bring the consumption of current or gas up to the full measure.

The system, as far as it concerns the regular solicitors, each with a territory, is probably familiar to readers of The Electrical Age. Systematic effort with present consumers is a newer development, with the Denver company, at least. This feature of the work is the result of gradual development through the experience of a number of years.

Early this year Henry L. Doherty, president, and Frank W. Frueauff, vice-president and general manager, brought the question of increasing business, through increasing the consumption of present consumers, to a practical basis. They determined that two ways were open: Installing additional appliances, and bringing up the consumption of those already installed.

Three men were assigned to the work. They obtained all the necessary information regarding consumption and appliances with respect to a given number of consumers, and went to work. At the end of three months their efforts began to tell to such an extent that it was decided to add four more men and also to employ young women to inspect and adjust appliances to give fullest efficiency, and at the same time seek opportunities for additional installations and increased consumption.

At first glance this method of approaching old consumers may seem somewhat of a deceitful nature. The service supervisor or young woman inspector must, of course, indicate that the mission of the call is to see that appliances and lights are in good condition and giving efficient service, and that all appliances are in proper working order. This is true, and the consumer appreciates the attention. He really gets something out of the visit. It is natural, and not forced, that he should be willing to do more business with a concern that looks after his welfare. What one consumer does others will do, and we have increased revenue selling for us and advertising as well.

At the present time the young women inspectors are making a complete canvass of the city, visiting every domestic consumer. While the bulk of their work pertains to the gas stove, they inspect the lighting as well, and look after any special electrical appliances that may be in use. Any defects that cannot be adjusted on the spot are attended to through the regular channels immediately.

In the case of the electric side, the inspector sees that all globes are in good condition, inquires about the porch light, and mentions special lamps for reading, as well as the numerous small appliances, such as electric irons, chafing dishes and hot plates. The young woman inspector does not make a determined effort to sell, but rather learns as accurately as possible just what prospects there are for a sale. Later she makes another call, to see that everything is working properly, and, in case some repairs were required, to see that they have been made properly. A close check is kept on the consumption, to determine whether or not there has been an increase. The representative is given all tips regarding the sale of appliances, and he looks after this part of the business.

The service supervisors, each with an allotted number of consumers, are engaged in putting appliances in proper shape, with the object of not only giving the consumer the best of service, but of bringing up the consumption. Where the service supervisor finds his most important mission as regards both consumer and company, though, is in supplying complete service, providing both gas and electricity for every purpose in the household. Next to this is the providing of all-year service of both gas and electricity for every purpose.

Consumers that have been brought to this point naturally are the best that can be had. Even then, though, the work is not ended, because it is always possible to introduce new appliances as they are placed upon the market, and also to bring about still further increase in consumption by evolving new uses for appliances already installed.

On the electric side, the service supervisors have had excellent success through rearranging lights to give better service, generally installing several lamps of low candle-power for one of higher power. In many cases they have completely rearranged the interior lighting of houses, generally adding considerably to the consumption. Porch lights, front and back, have helped to bring up consumption.

Small electrical appliances open the field that promises to be almost inexhaustible. Electric irons, curling irons, curling iron heaters, vibrators and warming pads are the most commonly used in Denver. As all of these appliances increase consumption chiefly in daylight, the business is exceedingly desirable. An encouraging feature of this work is the evidence that people are becoming educated to the use of smaller electrical appliances, marking the line that must always be passed before success can be attained.

With all of this work with old consumers the point of making friends and better feeling is never allowed to be in the background. The views of Mr. Doherty on this point are well known, and everything that he directs or does has this as one of the basic principles. Therefore in the end this work will do a vast lot of general good, something that always means direct business results under the best of conditions.

In the business section the regular representatives and special men work upon old consumers, necessarily. Their work is more directly new business, though, and is figured as such.

Along the line of increased consumption a good deal has been done. Most of the men have given some study to the question of proper interior illumination, as well as attractive and distinctive display lighting. This is bringing results every day.

The interior lighting and window lighting has developed a remarkable increase in business. Outside signs and outlining have multiplied and multiplied. Not only are new displays being added constantly, but business houses already using lights are increasing their displays. A great deal of successful work has been done in increasing the candle-power of lamps in exterior displays as well as interior and windows. The men report that this is not exceedingly difficult business to obtain, and constant additions to the revenue are being made along this line.

The employment of a special display lighting man, who is a draughtsman too, has had much to do with developing this line of business during the past two years.

In Denver the power business has grown by leaps and bounds during the last year. Two men are employed who do nothing but seek power business, and a number of the regular representatives have devoted much of their time to it because of the large revenue assured by a good power contract.

Perhaps the work of crowding out isolated plants is one of the most interesting features of the power business. Good success has been attained along this line in recent months, and it may be of interest to know something of the methods pursued. It has been comparatively easy to crowd out small steam plants and gasoline engines, but the larger installations, many of them almost new, have given considerable trouble.

Here is one instance: A year ago a new hotel of considerable size was opened on a downtown corner, its location being between a double hotel, one-half on one street and the other half around the corner on the other street. This double hotel contained an isolated plant. Overtures were made to supply the new hotel with power. To do this it would have been necessary to install another unit in the station. The new hotel asked for a rate covering the entire establishment, including considerable exterior lighting and a sign. After much dickering a contract was closed for two years.

Then the power man took a long breath and began figuring on how to shut down the plant in the adjoining building. He kept pegging away, talked with employees and help and the proprietor. Soon he learned that the local plant was unable to give steady service—that the starting of an elevator meant trouble with the lights. The additional appliances were installed, and soon it became evident that a new unit must be installed to supply current. This was the opening. Within a short time the case was so clearly presented that the hotel management threw out a fine lot of equipment only a year old and made a contract for two years.

Usually an isolated plant in a business block can be crippled by taking away its customers. This has been done successfully in Denver.

Large shops of all kinds are using central station drive now, including the railroads as well as the big machinery manufacturers. The individual motor drive has had much to do with this.

Incidentally it might be mentioned that the equipping of large appliances with gas has made great progress, and entire establishments are so fitted, making many manufacturing and business concerns completely all electric and all gas, the end that is being worked for systematically.

In the way of public lighting the Denver company is in excellent condition. Under a charter amendment adopted at the last election the company takes over the Lacombe street lighting plants, and obtains a contract for ten years for all street lighting. This contract provides for a considerable increase in the number of lamps on streets. This public lighting and the commercial service will be from the same pole lines.

Within the last year the company obtained a great deal of suburban lighting under a five-year contract for the city. A new scheme for lighting business streets will also return considerable revenue. Under this plan the main streets will be illuminated by clusters of lamps placed on ornamental pillars. The contract for this work has been let and the lighting service should be had before the end of the year.

While the soliciting of new business at the highest possible tension doubtless is the chief factor in bringing about the increase in revenue, the "man behind"—the man who forms the policy of the company and directs operations—has much to do with it. For instance, Denver has a flat rate for all display and window lighting. This is a question often discussed. Denver has the business, and that should be a good answer.

Then there is the Doherty readiness-to-serve rate. The Denver representative can spend a day telling about the number of complaints this rate has adjusted, the number of additional appliances it has sold, the increased consumption it has brought. There are also many other influences which have a share in the policy of the company, and all have much to do with opening the way for the man who actually closes the contract.

New York Meeting of the American Electrochemical Society

THE tenth general meeting of the American Electrochemical Society was held at Havemeyer Hall, Columbia University, in New York, on October 8 and 9.

The members were welcomed by Prof. C. F. Chandler, who spoke of the large field open to the work of the society, and referred to several cases in which electrochemical methods had simplified metallurgical processes. President Carl Hering, in responding, thanked him in the name of the society.

The first paper, on "A Formula for the Helmholtz Concentration Cell," by Prof. H. S. Carhart, was read by Dr. W. D. Bancroft, in the absence of the author. "Visible Migration of Particles Between Electrodes" was the title of the next paper, by Carl Hering. The author described the movements of minute particles between electrodes in a liquid, these being found as a result of microscopic researches made in conjunction with Dr. E. F. Northrup. These particles moved along direct lines from one electrode to the other, some traveling with the current and some against it.

In a mixture containing particles of different kinds, one traveled with the current and the other kind against it. In passing one another the different kinds deviated from their paths, apparently exerting a mutual repulsion. This phenomenon, it was thought, might explain some of the peculiar effects obtained occasionally in electrolytic processes.

Dr. Bancroft sought to explain the action by attributing it to a process the reverse of electric endosmosis, in which the diaphragm is stationary and the liquid moves. In the present case, however, the diaphragm, being disintegrated, moved, while the liquid was stationary.

Mr. Hering disagreed with Dr. Bancroft, as he thought that the disintegrated diaphragm would always move with the liquid. He then described the effect of adding colloidal particles to produce a smooth and compact electrolytic deposit. The colloidal particles form a protective diaphragm at places where trees would otherwise form, thus making a smooth deposit. Only those particles which travel with the current towards the cathode produce this result.

C. A. Acker told of a recent patent issued in this country for a process employing gelatine or a gum in a plating solution. The particles collected on the high spots of the plated surface, and, introducing a resistance, helped to build up the low parts of the surface. E. A. Sperry referred to the use of a small quantity of glue in the Betts electrolytic process for refining lead.

S. S. Sadtler then described some laboratory appliances for fusing materials by electricity and for other work.

"Copper Cathodes in Nitric Acid," by J. W. Turrentine, was the title of the next paper. This also was read by Dr. Bancroft, the author being absent. Using a copper cathode in a dilute nitric acid solution, copper nitrate was formed at the anode, while at the cathode the nitric acid was reduced, forming nitric oxide, as indicated by the brown fumes given off.

An aluminum-magnesium cell was

described in a paper by G. H. Cole and H. T. Barnes. Dr. Bancroft abstracted the paper. In the cell described, current flows momentarily from the aluminum to the magnesium, the cell then reversing its action. The electrolyte consists of potasium alum, either hydrogen peroxide being added or oxygen passed through. An e. m. f. of 2.14 volts is obtained.

S. S. Sadtler then abstracted a paper on "Melting Points of Some Cryolite-Alumina Mixtures," by F. R. Pyne. A paper by P. B. Sadtler and W. H. Walker, on "Double Decomposition of Zinc Sulphate and Sodium Chloride," and one by H. E. Patten, on "Some Factors Affecting the Distribution Law," were also read by Mr. Sadtler.

In the afternoon the members listened to a lecture at the College of the City of New York by Dr. Chas. Baskerville, on the use of ultra-violet light in the laboratory and in practice. The members then visited the Waterside station of the New York Edison Company. In the evening an informal dinner was served at Liederkranz Hall.

The first part of Tuesday's session was devoted to the subject of pyrometry. Dr. E. F. Roeber spoke of the great progress made in recent years in the application of thermometers and pyrometers, and of the necessity for an international agreement in the use of fixed points for calibration. He referred to the dependence which might be placed on the record from a pyrometer, thus doing away with the importance of skilled knowledge on the part of the workman.

A paper on the Bristol thermoelectric pyrometer was read by F. F. Schuetz, after which R. C. Whipple, of Cambridge, England, told of the progress in pyrometry in Europe, referring especially to instruments of the resistance type. He recommended the use of steam to keep the cold joint of a thermoelectric couple at a constant temperature.

The use of pyrometers in foundry practice was discussed by Dr. R. Moldenke, secretary of the American Foundryman's Association. Other speakers also discussed electric pyrometers, several types being exhibited.

Prof. Francis B. Crocker followed with a paper on "The Decker Primary Battery." The battery has been developed during the last two or three years by F. A. Decker, of Philadelphia. It is of the two-fluid type with zinc plates immersed in dilute sulphuric acid and graphite plates in a solution of sodium bichromate and sulphuric acid. The materials and chemical action are, therefore, similar to those of other batteries, the original features being found in the construction of the parts and the manner in which they are put together.

The size and number of plates employed in each cell depend upon the current required, but ordinarily there are two or three flat zinc plates about 5½ inches wide by 9½ inches high, each weighing about one pound. Each zinc plate and the dilute sulphuric acid surrounding it are contained in a flat porous cup. In order to form such a cup two unglazed earthenware plates with thickened edges and diagonal strengthening ribs are shaped separately in steel moulds, a special clay mixture being employed to obtain any desired porosity.

These plates are made extra thick to prevent warping in burning and produce true flat surfaces and straight edges. They are then united to form a flat cup, after which it is ground down on each surface to the desired thinness. In point of fact, the finished walls are very thin, so that light will show through them, which enables the degree and uniformity of thinness to be readily determined.

The exceeding thinness of the walls of these cups tends to reduce the internal resistance to a minimum for any two-fluid cell, and the fact that these walls are true permits the graphite and zinc plates to be placed close together, and thus to minimize the resistance. By actual test, the resistance is only 0.013 ohm for a cell of the kind described with two zinc and three graphite plates, all connections and the resistance of the plates themselves being included.

The negative plates are of graphite, being corrugated so as to offer large surface for the free action of the depolarizer, and also provided with thickened edges and diagonal ribs to give them strength, as well as to decrease their electrical resistance.

The space around the porous cups and graphite plates is filled with the depolarizer, consisting of a solution of sodium bichromate mixed with sulphuric acid, which is introduced into the containing vessel of hard rubber, comprising four cells. In order to assemble a battery, the two porous cups, each containing a zinc plate, with the three graphite plates, are placed in one of the cells of the containing vessel, other similar sets being put in the other cells. To supply dilute sulphuric acid to the porous cups each one communicates, through a small opening at the bottom, with a conduit in the base of the containing vessel.

The results obtainable from the Decker battery are shown by tests made personally by the writer. A cell of the form described having two zinc and three graphite plates, was discharged for a period of five and one-quarter hours at 24 amperes, the external potential falling from 1.9 to 1.3 volt. In other words, the cell gave 126 ampere-hours at an average voltage of 1.73, or 218 watt-hours. The cell was then shaken so as to stir the liquid and gave 24 amperes for fifty-three minutes longer. This corresponds to the condition that would exist in electric vehicles, boats and train lighting.

The total output, therefore, was 147 ampere-hours at 1.684 average voltage, or 247.55 watt-hours. As the complete cell weighed 16 pounds 14 ounces, including all solutions, connections, etc., the output was 14.7 watt-hours per pound of total weight, which is an output about twice as great as that obtained from the standard types of storage battery now manufactured and used.

The weight of zinc, sulphuric acid and sodium bichromate required to give one horse-power-hour, assuming all materials to be thrown away after being used once, would cost 35 cents, which is a high rate. It should be remembered, however, that the several important advantages will offset this item for many purposes and in many places. The first cost of the battery is not high, and the depreciation is very small.

The Association of Edison Illuminating Companies

AT the recent convention of the Association of Edison Illuminating Companies, held at the Hotel Frontenac, Thousand Islands, N. Y., the following officers were elected:—President, Alex. Dow, of Detroit, Mich.; vice-president, Thomas O'Dea, of Erie, Pa.; treasurer, Louis A. Ferguson, of Chicago, Ill.; secretary, Ernest H. Davis, of Williamsport, Pa.

Executive committee:—Alex. Dow, Detroit; Joseph B. McCall, Philadelphia; Samuel Insull, Chicago; J. W. Lieb, Jr., New York City; Charles L. Edgar, Boston; Thomas E. Murray, New York City; L. A. Ferguson, *ex officio*, Chicago; E. H Davis, *ex officio*, Williamsport.

Various Types of Lamps and Practical Hints on Illumination

By S. B. BURROWS, of the Edison Electric Illuminating Company of Brooklyn

A Paper Read at the Recent Convention of the Association of Edison Illuminating Companies

A CORRECT ARRANGEMENT OF LIGHTS IN AN ART GALLERY

THE value of illuminating engineering is being more thoroughly understood with the development of this recently recognized science, for companies are realizing as they have not done before that the satisfaction and good-will of the customer, which is a most important asset of any company, can best be secured by giving all the illumination possible from every kilowatt-hour of current used.

The illuminating engineer's duty does not cease when an installation has been planned and installed, but he must seek to educate the consumer to the proper use of his light units so that he will get the greatest efficiency out of his lighting service. The available data bearing on this subject is meagre, and it has been left to those who are making a specialty of this science to learn, by experiment and study, the effect of different units upon the optics, and the source best adapted to a given purpose, with accessories, distribution and control.

GOOD ILLUMINATION IS OBTAINED WITH A CHANDELIER ARRANGED AS HERE SHOWN

A SHADE WITH GREEN EXTERIOR AND WHITE PORCELAIN INTERIOR. THE BEST STYLE FOR READING OR WRITING

In discussing the subject of "Various Types of Lamps and Practical Hints on Illumination," the writer will aim to present the types of lamps best suited for various purposes of commercial illumination.

Practical illumination must include usefulness, economy in distribution and control, artistic and æsthetic arrangement, and harmony with optical laws. Reversing the order and referring to the last first, we find that

AN EXAMPLE OF THE ILLUMINATION OBTAINED WITH CONE LIGHTING

sizes ranging from 25 to 100 watts with an efficiency of $2\frac{1}{2}$ watts per candle and a life of 800 hours. This lamp indicates encouraging and immediate prospects in the smaller units, and it is to be hoped that the rumors of greatly increased efficiency in incandescent units will in the near future be fully verified.

Reflectors, globes and shades play a very important part in illumination, both for reflecting and diffusing the light; and very often the effect of well-distributed units is spoiled by the unnecessary or improper use of reflectors or globes. To illustrate the wide difference in this class of ware the accompanying illustrations are presented.

The best uniform illumination is obtained by distributing small units over the space to be lighted; but this is not always practicable, for one must consider the architecture and purpose for which the space is used.

Many features must be considered, and one of the most important is the colour scheme. We know that colours are noticeable simply on ac-

A GOOD EFFECT FOR WINDOW LIGHTING IS OBTAINED WITH FRINK REFLECTORS, MANUFACTURED BY I. P. FRINK, OF NEW YORK

THIS FANCY GLASS REFLECTOR OFFERS A POOR REFLECTING SURFACE

opticians insist that the majority of weak and strained eyes are due to artificial light, such being either too intense or not properly shaded. On this point the following law should be followed in practically every illumination:—No light should enter the eye direct from the luminous centre.

A WHITE PORCELAIN SHADE. POOR FOR READING

In treating the several heads, it may be well to generalize, rather than outline minute details of arrangement, because persons' tastes differ, and the illumination must not only comply with general rules, but must also please the taste of the customer; therefore, fixed rules cannot be established, except along general lines.

The most recent development of general illumination has been toward the larger and more intrinsically brilliant units, for, while there has been a marked increase in the efficiency of lamps consuming from 100 to 600 watts each, the smaller units have not made corresponding progress.

In the paper, however, presented by Mr. Willcox at the National Electric Light Association convention at Atlantic City, data were presented on the new metallic filament lamp in

A WHITE PORCELAIN SHADE. THIS KIND SHOULD NEVER BE USED

A HOLOPHANE REFLECTOR. A GOOD TYPE TO USE

count of the reflection of certain rays of light, others being absorbed; and this will make a wide difference in the illumination of two rooms of opposite colours, with the same source of light.

For instance, white will reflect 85 per cent.; yellow, 45 per cent.; light pink, 35 per cent.; light blue, 25 per cent.; brown, 15 per cent.; black, 5 per cent.; chocolate, 4 per cent. Hence the number of candle-feet necessary in a room decorated in white would have to be increased for a yellow or other coloured room in proportion to the light absorbed.

The question as to which scale is the best to follow in figuring a given illumination is a moot question; but, in the writer's opinion, the best standard is the candle-foot, though he has satisfactorily used the scales of watts per square foot and watts per cubic foot, the former when the object to be lighted was on a plane surface, and the latter in general illumination, such as church lighting.

Of course, as the source of light is raised, the light on an underlying surface will diminish according to the law of inverse square, i. e., the light from a given source varies inversely as the square of the distance; so that the scale of watts per square foot will vary with the height of the lamps and their efficiency.

The following hints on illumination are offered for the several classes of buildings as indicated:—

THEATRE LIGHTING

In every building the illumination and accessories must correspond with the architectural lines and the decorations. The quality of light in a theatre must be soft, well distributed, and shaded from the eye in all instances, for the eyes are tired and distended after having looked upon the brilliant footlights, and the mellow light is needed as a restful contrast. It will be noticed that the decorations are usually in some dark colour to correspond with this idea, as also to give the appearance of space.

Every lamp should be concealed from view or equipped with a globe. Frosted lamps will also serve the purpose of diffusion. Studded lights are the most appropriate in this class of illumination, as they can be made to carry out the line of the buildings and the distribution is of the best. The incandescent lamp of 16 or 32 candle-power is the best lamp for this purpose, on account of the quality and quantity of light in each unit.

Electroliers should be tabooed, as they tend to concentrate the light.

Under the balcony the units can be best aranged by concealing them in hemispheres, and on the forward side of the balcony units can be best arranged to throw the light forward, the units being high enough to be out of the range of vision. The same

AN OPAL REFLECTOR. USELESS AS A REFLECTOR OR DIFFUSER

arrangement is good for the extreme rear of the theatre, the units being placed at the junction of the ceiling and wall.

Frosted 4-candle-power lamps around the usual arch of the boxes will add materially to the artistic effect. The lighting of the lobby is a different proposition, as brilliancy is desired. Electroliers can be used to advantage with side wall brackets, or the brackets can be placed around the top of the pillars, or the units themselves can be artistically imbedded in the decorations.

CHURCHES

In this class of lighting the engineer encounters a great diversity in architecture, and, therefore, a great diversity in the styles of illumination exists. For instance, there is the Grecian or Corinthian, where studded lights would be out of place, as, in

A GOOD DIFFUSION IS OBTAINED WITH THIS STYLE OF HOLOPHANE GLOBE

fact, they would be in most of the ancient types of architecture. But in the Gothic and modern, this style of lighting can be used to advantage, as the general lines of the building are plainer than in the Grecian.

The denomination of the church will often make a difference, for you would not plan to illuminate an Episcopal or a Roman Catholic church with studded lights. These two church bodies are symbolic and present to the worshipper the Almighty in symbols, making the chancel beautiful and æsthetic, and denoting some attributes of the worshipped. So the general illumination must be along the same lines, with fixtures appropriate to the building, keeping out the more modern styles.

There is the other extreme, as in some of the Protestant churches, where the puritanical ideas of plainness and severity find expression; here the studded lights can be used, arranged in the shape of a cross, a star, a circle, or a Maltese cross, each denoting some religious theme, but in plain lines.

A good style of illumination for the church is cove lights in conjunc-

A GLOBE WITH A GROUND GLASS INTERIOR. THIS GIVES A FAIRLY GOOD DIFFUSION

A POOR ARRANGEMENT OF LIGHTS FOR A SHOW WINDOW

PERMISSIBLE WINDOW ILLUMINATION FOR A BUTCHER SHOP

tion with a general illumination, the hidden light to be switched on when the sermon begins and the visible sources to be dimmed, which will shed over the church a soft light, appropriate and not injurious to the eyes.

The control of these lights should be elastic, so that from one-eighth to the whole can be used, as desired. Incandescent or meridian lights are the best units, but the writer hears of satisfaction with the Nernst.

DANCE HALLS AND THE LIKE

To take the other extreme in lighting, let us consider the dance halls and ballrooms. The first requisite is uniform illumination, with no shadows, and this can best be accomplished by studding small units over the ceiling and upper walls, and then, if there are any recesses, lights can be arranged in these in conformity with the other lighting. The accompanying illustrations will exemplify the correct lighting of a ballroom.

Arcs or Nernst lamps are not permissible, for they give an impression of light and shadow rather than of uniform illumination, and their effect upon the face is not so pleasing as the incandescent light.

BANKS AND OFFICE BUILDINGS

The lobbies of this class are generally of the same style as theatre lobbies. In all cases of bank and office lighting there are two considerations, one the general illumination, and the other the placed lighting over the desks. The general illumination in banks should be designed, not only to illuminate the lower region of the public space, but to throw enough light on the ceiling and upper side walls to bring out the decorations and lines of the building. Studded lights can be used to good effect.

There are three points to be noted in the placed lighting for the use of the clerks. The light source should be shaded from the eye by a dark-coloured shade, preferably green on exterior and white porcelain finish inside. Frosted lamps should be used to prevent striations, and the light source should not be too intense. An illumination of from 2 to 4 candle-feet is plenty. In other words, an 8-candle-power lamp should be placed 18 inches to 2 feet from the surface to be lighted.

This illumination is the correct standard for reading. The light should come from behind the left shoulder. For writing, the light

A PROPER MERIDIAN REFLECTOR

AN OPAL GLOBE WITH A POOR DIFFUSING SURFACE should come also from the left, but farther out and forward, so as to prevent shadow from the pen or hand.

The writer has not seen anything but incandescents used satisfactorily for the illumination of banks. The arc and similar illuminants would not give satisfaction, on account of the size of the unit and its tendency to cast shadow, certainly not enhancing the appearance of the interior.

The lighting of an office building is practically the same as in a bank. For the desks, etc., a line could be run around the room at a distance of 2 feet from the floor, with plug outlets at intervals to accommodate a given number of desks. This would arrange for the placed lighting.

The general illumination should be preferably from above, as side lights would tend to throw shadows when one is writing at the desk, and, while the bank's working force is enclosed behind a partition, the office buildings or rooms are usually open, and the general illumination will affect the light on the desk to some extent.

In our Brooklyn office we use the arc concentric diffuser, with no placed lights, and the illumination for writing or reading is as nearly perfect as it could be and is free from shadows. This lamp, however, is not attractive in appearance, and might not be acceptable in a bank or small office; but for large office rooms the illumination is good.

STORES

Perhaps the largest part of our light load comes from this class of business, and the writer has specialized somewhat on this field of illumination. The first point we notice in talking with a storekeeper is that he wants all the light he can get for a given sum of money. It is all right to talk about artistic effects to him, but he is more interested in dollars and cents and economy in lighting. The advantages of an attractive store are recognized, but the storekeeper wants to be sure that he can get them at a reasonable cost.

What general rules can be followed to this end? First, we will consider the several kinds of stores, as to interior lighting. The writer has found that, in cases where economy is the first consideration, the best result is generally obtained from incandescent units at a height of from 8 to 10 feet from the floor, and with the arc from 12 to 15 feet high; the units between these in size range correspondingly.

FURNITURE STORES

One of the latest propositions dealt with has been a furniture store, and the installation consists of high-efficiency units in the several sizes. Furniture shows up better under a yellow light than under a white light, and when a patron purchases he will in most cases use the furniture in a home with the first quality of light, and wants to know how it is going to look when there.

Then, again, the high-efficiency or other incandescent lamps are easily renewed, while in all cases the lamp shedding white light must be trimmed, making it necessary to move the furniture, with a liability of scratching. For carpets, also, the yellow light is preferable, and a unit of about 100 candle-power or more, fitted with a reflector to throw the light on the carpet (which is usually hung on a movable form) will prove satisfactory.

The units in this class of business should be of individual control, with the possible exception of the main floor, for many times the salesman will need only one or two lights at a time, and they can be readily used as required without wasting current. A good arrangement is to have a row of pilot lights, controlled by a switch, at the entrance to each floor.

A GOOD CHANDELIER INSTALLATION IN A CHURCH

ANOTHER EXAMPLE OF CHURCH LIGHTING, SHOWING THE UNITS WELL DISTRIBUTED

"DREAMLAND," CONEY ISLAND, HAS PERHAPS THE BEST LIGHTED BALLROOM IN THE WORLD

ANOTHER BALLROOM IN WHICH THE LIGHTING IS NOT SO EFFECTIVE AS THAT AT "DREAMLAND"

A BALLROOM ILLUMINATED BY CLUSTERS OF LAMPS

In using the new high-efficiency unit it is advisable to hang the units 10 to 12 feet from the floor, and have them fitted with the style C or concentrating shade, as the light will diffuse of itself below a certain plane and at the same time give greater efficiency with style D or distributing reflector.

MILLINERY STORES

The arc or the Nernst lamp should be used for this business, as the white lights show the delicate colours to best advantage. The writer's belief is that the arc is better than the Nernst for this class of illumination. The concentric diffusers are used in Brooklyn millinery stores with satisfaction.

MEN'S FURNISHINGS

The same principle as to colour will apply to clothing stores, though perhaps evening clothes, since they are to be worn under the incandescent light, should be fitted under the incandescent unit.

For a men's furnishing store the cluster, either the arc burst or the pagoda arc, is a good arrangement; and such units are attractive and efficient. In one such store we have recently changed three arcs to four Benjamin arc bursts, and with a saving of 400 watts the resultant illumination is a big improvement.

The Nernst lamp or the high-efficiency lamp is being used in Brooklyn in this class of stores. The Nernst gives the better colour value, and in the two and three-glower size the illumination is good.

The arc should not be used in small stores, for two reasons: first, the size of the unit and the usual height of ceilings in small stores will not permit of good diffusion; secondly, unless a number are installed, shadows are frequent.

JEWELRY STORES

There is a diversity of opinion as regards this style of illumination, some engineers claiming the white or bluish light should be used, others that the incandescent is best. The advantage claimed for the arc lamp is that it accentuates the bluish tinge in diamonds, and that the larger the unit of light the more intrinsic brilliancy the diamond will have. As to the other classes of jewelry, the incandescent unit is, in the writer's opinion, decidedly the best light.

A good arrangement of units is to have a cluster of 187 to 250-watt, high-efficiency lamps with D shades in the centre of a store, placed high to give the store an appearance of brightness, and have special lighting either on cord pendants over the cases, or reflectors inside the cases, the latter being the better, for the two-fold reason that the observer cannot be between the light source and jewelry and that less light is necessary.

Studded lights make a very pretty store if the decorations will allow their use.

OTHER STORES

Most other stores are in the one class, so far as interior illumination is concerned, and the principles presented will apply to cigar stores, drug stores, butcher stores, groceries, and saloons. Practically all call for the same illumination, and if there is any difference at all it is in the brilliancy desired. For instance, a drug store, saloon, or cigar store may need more light than the butcher or grocer, and the lights range from $1\frac{1}{2}$ candle-feet to 5 candle-feet, or, if watts per square foot, from 1 to 3 watts per square foot, determined by colour of store, height of room and units used. The number of lamps required for a given service equals the above factor multiplied by the area in square feet, divided by the wattage per lamp.

No definite rule can be made as to the watts per square feet or candle-feet needed in an installation, for so many things must be taken into consideration that no definite figures can be given until these factors are known; therefore, no scale is presented in this paper.

DEPARTMENT STORES

It would seem at first glance that, as the department store is a consolidation of the smaller stores heretofore considered, the illumination for each department would coincide with the corresponding small store; but there is a factor which governs this, namely, uniformity. For large spaces of this kind the arc lamp without doubt is the unit to be used, as the colour values are good and the majority of goods shown are "day goods," though department stores are providing separate rooms for the exhibition of evening goods.

Incandescent and arc lamps should not be used in the same space for the same purpose. That is, while arc lamps may be used for the general illumination, incandescent units should not be used also for general illumination in that room, but may be used for special purposes, such as lighting show-cases; to alternate the general illumination between arcs and incandescents would be very poor arrangement. An opalescent globe should be used with arc lamps, to remove the glare and improve the colour values by filtration.

WINDOW LIGHTING

There are two distinct divisions in window lighting, the concealed and the open, and each serves its purpose. One is to attract attention to the store itself, the other is to show the goods in the window.

A STORE LIGHTED BY ARC BURSTS MANUFACTURED BY THE BENJAMIN ELECTRIC MANUFACTURING COMPANY, OF CHICAGO

It is obvious that the usual border arrangement of the lights would not show goods to the best advantage, first, because most of the light which is on the horizontal is being thrown on the street, and, secondly, the rule which was presented in the first of this paper, that the light should not enter the eye direct from the luminous centre, is being violated. When one looks at a window lighted with visible units, the light itself attracts the eye, and the sight is for the moment blurred, so that when we look at the goods they are not distinct; it was the light units which attracted us, not the goods.

Take the opposite. With concealed, reflected light, the window is bright, but the light is centered on the goods, which reflect the light to our eyes, attracting our attention to the display and not the source of light.

When the open border lighting is used, a frosted lamp should be utilized to reduce the intrinsic brilliancy, and an 8-candle-power unit is large enough to serve the purpose of attracting attention. In the concealed style there are two divisions, trough reflectors and cone reflectors, including in the latter all cone-shaped reflectors, whether moulded glass or silvered.

The trough reflector should be used where the window display rises from the bottom of the window in the shape of models for dresses, or where

ARC LAMPS WITH CONCENTRIC DIFFUSERS FOR OFFICE LIGHTING

the back of the window is used, as the distribution of the reflector is toward the rear and downward. The cone reflector should be used where the base of the window alone is to be used, so as to concentrate all the light upon the goods.

Nernst lamps or units of the same size are used satisfactorily in Brooklyn with reflectors to throw the light down, the unit being high enough not to interfere with the sight.

The writer has in mind a window where the trough reflector is used in conjunction with an electrolier, but the latter is fitted with Holophane globes, which eliminate the intense light factor by diffusing the light. This arrangement is both attractive and efficient.

The tendency of the cone reflector is to produce spots, while with the trough reflector the illumination is uniform and even. In lighting the window with either the border lights, trough or cone-reflectors, the units should be on alternating switches for purposes of economy.

PICTURE GALLERIES

The best arrangement for this class of lighting is the trough reflector, for the same reasons given above. A new arrangement, at least to the writer, was suggested by the desire of a customer to light a small gallery economically, both as regards wiring and use. The arrangement installed was a Frink reflector on a pivot, run along the centre of the room and placed high. A handle was attached so that the reflector could be turned to either side of the gallery, the result being highly satisfactory.

In the Metropolitan Museum of Art, in New York City, the luminous arc is being installed, and the experts of the gallery are of the opinion that this gives the best light of any artificial source.

RESIDENCE LIGHTING

The class of residences considered will be those belonging to the "middle class," where economy is necessary. Where the person is willing to spend a large amount the engineer can give full play to the artistic, but most of our residence business is with people who practice economy.

PARLOR

This room is used for entertaining and receiving callers only, so the illumination should be general. In the average room of 12 by 15 feet a centre electrolier with the units extending about a foot from the ceiling and four or five 8-candle-power lamps will give a good light, the units pointing outward at an angle of 45 degrees and equipped with either an etched shade or Holophane shade. One or two plug outlets can be utilized for a lamp, fan or other apparatus.

In a room of this shape the centre fixtures are sufficient, but when the room is long and narrow side wall brackets can be used to advantage. One point in this style of illumination is to have the lights pointing downward, for it can be readily seen that otherwise the light would be thrown on the ceiling and wasted to some extent. The side wall brackets can be fitted with Holophane reflectors in ground glass shades, and can be either pointing upward or downward. This is a great deal a matter of taste, as both arrangements can be made to conform to the other illumination by means of proper shades.

For the lamp, which is ornamental rather than useful, a light of small candle-power can be used. Two 4-candle-power units will be sufficient in most cases, and in any case two 8-candle-power units would be enough, which would be determined by the density of the art glass canopy.

SITTING ROOM

This room is used for sewing, reading, and is the living room of the house, so that general, and some special, illumination is needed. A centre fixture with three or four outlets, and an outlet near the desk, will prove satisfactory, but each purpose must be considered.

In reading, a light of 2 to 4 candle-feet is sufficient, and also on the desk or for sewing. While, theoretically, a light from above and behind is the best, the writer's own taste is for the old-fashioned reading lamp with a white enameled interior and green exterior, first, because the resultant light is good, and, second, the eyes, on being lifted from the book, do not encounter the same intensity, but are rested by the soft light diffused by the green shade. With the other style the light is practically the same, whether one's eyes are on the book or not,—in fact, in all home lighting, if the illumination be uneven, the eye is rested in the change from bright to less bright spots.

For sewing, an extension cord can be attached to an outlet and the lamp hung directly over the machine.

DINING ROOM

The one point to be illuminated in this room is the table, and this can be done by one unit with a large reflector. The reflector can be covered with some dark material in keeping with the decorations, either crepe paper or some texture, which will serve the purpose of an expensive glass design.

Side wall brackets are not essential, but can be used if at any time a more general illumination is desired, such as when the guests are seated around the sides of the room.

KITCHEN

The kitchen of to-day is not the large one our ancestors were accustomed to, and in the average home one unit in the kitchen is sufficient. Cravath and Lansing recommend a 4-candle-power unit over the sink, stove and table, with reflectors easily kept clean, on account of the grease; these units should be on brackets pointing downward to have light below 45 degrees.

It is admitted that with this arrangement, the equivalent of a 16-candle-power unit, the general illumination will not be good. The deduction, therefore, is that a centre unit for general illumination would also be necessary, and that the three 4-candle-power units would be used in concentrating the light over the sink, table and stove only. In a small kitchen such units would be unnecessary, as a lamp placed high, with a good reflector, will shed plenty of light for all purposes, and at the same time be economical. In a large kitchen the arrangement suggested would be ideal with an 8-candle-power or 16-candle-power unit for general illumination.

HALLS

In the halls a bright light is not necessary. In the lower hall or entrance an upright fixture from the newel post in a foyer hall gives good illumination, though the overhead light is to be preferred, for the tendency of the unit upon an upright is to throw the light up, whereas it should be thrown down. A ground glass or opal sphere can be used, and is, perhaps, more artistic than a common reflector or shade, the lower hall unit to be controlled by a two-way switch.

In the upper halls a light at the head of the stairs on a side wall bracket, to serve both for the stairs and hall, and if the hall is long, another unit at the opposite end, will light the hall well.

BATHROOM

An 8-candle-power unit on each side of the mirror, either with a shade or frosted lamp, will suffice, controlled by a switch at the entrance.

BEDROOMS

The most economical arrangement here would be to have a centre fixture of two or three lights and use the movable brackets, so that the light can be used at the dresser, or, if a reading light is desired, it can be placed near the bed. In a small or hall bedroom a side wall bracket with an 8-candle-power lamp is enough.

The most convenient arrangement is to have two 8-candle-power units on each side of the dresser controlled by a switch on the side of the dresser or wall, the centre fixture to be controlled by a switch by the door and fitted with proper reflectors. In all houses fitted with electric light, an extra switch should be provided in the bedroom controlling one light in each room on the first floor and the halls, so as to be able to light these rooms instantly in case of emergency.

The turn-down lamps can be used to splendid advantage in residences. There are many places where a bright light is not required continuously, but where a dim light is of great service. The turn-down lamps fill this need fully and at slight operating cost. Every residence using electric service should have a supply of these lamps.

FACTORIES

In factory or machine shop lighting the problem is generally the same as in a large office building. Each operator should have a unit over his machine, and this will hold true in most all factory lighting and the like. The incandescent lamp should be used for special lighting.

In foundries, etc., where the walls are dark and the light is not so much on a special line, a lamp is needed to throw the light down and to be near the colour of daylight. The arc does not meet both these requirements, and the lamp which has proved most satisfactory in Brooklyn is the Nernst lamp, as the unit is small and can be distributed, and the efficiency is high. The light from the arc is absorbed by the side walls, and the Nernst distribution is below 30 degrees.

SIGN LIGHTING

The tendency of a customer is to put too large a unit in a sign, thinking to make a greater display, whereas he is more likely spoiling the effect of his sign. The smaller the candle-power in a lettered sign, the more distinct is the outline of each letter; with a unit too large, the sign presents a blur.

A 4-candle-power unit is large enough for any ordinary sign, and a 2-candle-power unit has proved satisfactory in outlining letters. For the panel sign a 4-candle-power lamp is sufficient, although 8 candle-power will, of course, give added illumination; if a reflector is placed above the upper lights the sign will prove more readable.

SPECIALTIES

Several types of lighting units have recently been pushed commercially for special uses.

Luminous Arc.—The luminous arc is used quite extensively in many cities, notwithstanding the cost of the lamp, and it certainly attracts attention by the brilliancy and colour of its light. It probably has a permanent field within a limited scope, but its advertising value will probably suffer as the number of lamps in use increases. For general illumination, independent of advertising uses, this lamp is not well adapted.

Cooper-Hewitt Tube.—This type of unit is occupying a field in which it is giving good service. For photographic work it is very successful, and its use in factories and large buildings is becoming more general. The predominant violet rays are objectionable, although not injurious to the eyes.

Moore Tube.—The Moore tube is now being energetically pushed by the manufacturers, and is giving satisfaction in a number of places. Its colour is more pleasing than the Cooper-Hewitt, and its efficiency is attractive, though its use is limited at present to large floor spaces. The commercial development of this type of lighting will be watched with interest.

Annual Meeting of the Electrical Trades Exposition Company

THE annual meeting of the stockholders of the Electrical Trades Exposition Company was held in Chicago, Ill., on Tuesday, September 11, for the purpose of electing directors for the ensuing year. The following directors were elected:—Samuel Insull, Charles E. Gregory, G. H. Atkin, Stewart Spalding, Ellsworth B. Overshiner, George B. Foster, T. P. Gaylord, Homer E. Niesz, H. B. McMeal, W. W. Low and J. P. Cracraft.

At a meeting of the board of directors immediately following the stockholders' meeting the present officers were re-elected, as follows:—

President, Samuel Insull; vice-presidents, Ellsworth B. Overshiner and Charles E. Gregory; treasurer, John J. Abbott; secretary, Stewart Spalding.

Managing Director Homer E. Niesz reports over 80 per cent. of the floor space in the main exhibit hall of the Coliseum Building already contracted for, for the second annual electrical show, to be held January 14-26, 1907.

American Institute of Electrical Engineers

Papers at the September Meeting at New York

THE first meeting of the American Institute of Electrical Engineers after the summer vacation was held at the Edison Auditorium, in New York, on the evening of September 28. The meeting was called to order by President Samuel Sheldon, after which Secretary R. W. Pope announced that 191 associate members were elected at the meeting of the board of directors.

In addressing the members, Dr. Sheldon took for his topic "The Work of the Institute." At the last convention, held in Milwaukee, he said, the question of the work of the branches of the Institute and their relations to the executive officers in New York revealed the fact that there was considerable lack of information concerning the scope of the Institute work and the method of carrying it on. The growth of the Institute as a national organization and the extension of its usefulness to its membership is so largely dependent upon the intelligent co-operation of the local organizations that it seemed desirable that all should be familiar with its work.

He then described the duties of the secretary, and gave statistics showing the amount of routine work performed by the secretary's office. The board of directors made appropriations, approved bills and recommendations from committees, and determined and outlined broad questions of policy. Certain of the powers of the board of directors may be delegated to an executive committee of seven members.

Much of the work is performed by committees under the immediate direction of their respective chairmen. The board of examiners receives from the secretary all applications for membership or for transfer, passes upon the qualifications of various applicants, and makes recommendations to be acted upon by the board of directors.

The work of the committee on increase in membership is to place before non-members the advantages to be obtained from membership in the organization. The committee on telephony was appointed to take measures to increase the usefulness of the Institute to the art by arranging for meetings designed to bring out discussion from members who are too busy to prepare papers, these meetings to be held at various branches instead of at New York.

The work of the committee on local organizations is to bring the various branches into closer co-operation, and to increase the effectiveness of each local organization. Dr. Sheldon here outlined a number of suggestions, in part as follows:—Limit the number of members of the local executive committee to five; branches should be in constant communication with the secretary's office as to their plans and the progress of their work; they should put forth organized efforts toward increasing their membership; they could suggest to associate members the desirability of applying for transfers to the grade of member; original papers should be presented instead of only those read at New York; an annual calendar of the meetings should be sent to the secretary's office.

The committee on high-tension transmission had, during 1902-3, collected data on this subject, published it in a volume, and placed it on sale. In view of the development since that time, the reappointment of the committee had seemed desirable.

The library committee, besides installing and systematizing the present library in the new quarters, will effect some organization for co-operative management in connection with the libraries of the mining engineers and the mechanical engineers. The committee on bibliography expects to have on the press by December a chronologically arranged, annoted bibliography of the Wheeler gift.

Upon the editing committee rests the responsibility of the publications of the Institute. The work of editing, however, should be delegated to the editor of the proceedings and done in the secretary's office. The committee could then devote itself to the matter of making the proceedings of greater interest to the members by inserting announcements from the executive officers and news concerning the individual members and branches.

Dr. Sheldon then briefly referred to the work of the two members, Prof. F. B. Crocker and C. O. Mailloux, of the committee on standardization, who would represent the United States on the International Electrotechnical Commission. The work of the committee on the national electrical code, the committee on law, the committee on papers, the committee on finance, and the building fund committee, was also briefly described. The last-named committee had raised $132,000, of which $94,000 had been paid. The whole amount of this fund is $180,000. The building is expected to be ready for occupancy by the first of December.

Following the president's address, a paper on "The Effect of Iron in Distorting Alternating-Current Wave Form," by Frederick Bedell and Elbert B. Tuttle, was read by the former. The paper, in part, follows:

It is well known that in a circuit containing no iron, an impressed sinusoidal electromotive force will cause a sinusoidal current to flow, the current lagging behind the impressed electromotive force by an amount depending upon the relative values of the resistance and inductance, the latter in this case being constant. Assuming inductance alone in the circuit, the sine current which flows lags 90 degrees behind the sine electromotive force and represents no power, the power factor (cos. 90 degrees) being zero.

It is also well known that if the conductors of the circuit encircle iron, the inductance will no longer be constant. The current resulting from an impressed sinusoidal electromotive force will no longer be sinusoidal, but will be distorted and consist of a first harmonic or fundamental sine current of the same frequency as the electromotive force, and harmonics of 3, 5, 7, etc., times the fundamental frequency.

One of the first studies of this subject was made by Ryan and Merritt, who, from experimental curves of current and electromotive force, determined the hysteresis loop for the iron of a transformer. Steinmetz, taking certain hysteresis loops and assuming a sinusoidal electromotive force, has determined the complex current wave for a great many cases.

The purpose of the present writers was to study more fully the relation between the harmonics introduced by iron into the current wave, and the hysteresis loop of the iron to which these harmonics are due. For example, it can be shown that certain harmonics defined by their amplitude and phase with reference to the fundamental, can be produced by iron; others cannot, the latter being excluded as impossible by the determination of some physical limitation.

The conditions that hysteresis in iron causes it to absorb rather than to give out energy, at once renders certain harmonics impossible. The fact that the current can have a maximum value only coincident with the maximum value of induction in the iron is likewise a limitation. Again, the fact that after saturation the permeability decreases with the increase of the induction is a further limitation.

In case of a sine electromotive force and a complex current wave due to iron, the harmonics in the current wave (being 3, 5, 7, etc., times the frequency of the electromotive force) can represent no power. Any power must accordingly come from that part of the complex current wave which is of the same frequency as the electromotive force.

If this current lagged 90 degrees behind the electromotive force, as it does with no iron present, there would be no power, as has already been pointed out. But the current of fundamental frequency is shifted ahead by an angle, ψ, of hysteretic advance due to the iron, so that it lags less than 90 per cent. behind the electromotive force; consequently it represents power, this being the power expended in hysteresis.

The current of fundamental frequency considered might be taken either as the fundamental sine curve, as we analyze the current into components of 1, 3, 5 times the frequency, or, as the equivalent sine curve, which is a sine curve equivalent in its effect to the fundamental and higher marmonics combined.

If the electromotive force impressed on a coil be sinusoidal, the magnetic flux threading the coil will also be sinusoidal, and in phase 90 degrees behind the electromotive force. This is true whether the coil embraces iron or not.

If the coil does not embrace iron, the current also is sinusoidal and 90 degrees behind the electromotive force; the flux is in phase with the current, and proportional to it, as shown in Fig. 1. The inductance L

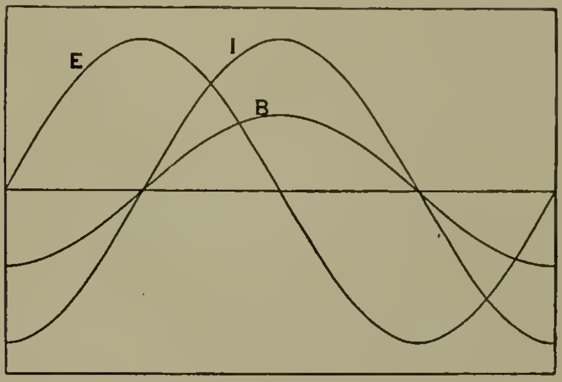


FIG. 1.—SINUSOIDAL CURRENT I AND INDUCTION B, LAGGING 90 DEGREES BEHIND THE ELECTROMOTIVE FORCE E WHEN NO IRON IS PRESENT

is constant, and hence the induction B is proportional to the current I and the magnetizing force H, the permeability being constant. The hysteresis loop, plotted between B and H, then becomes a straight line.

With iron present, inductance and permeability are not constant. The induction B is no longer proportional to the current I and the magnetizing force H, and with the induction B sinusoidal (due to sine impressed e. m. f.), the current I is not sinusoidal;

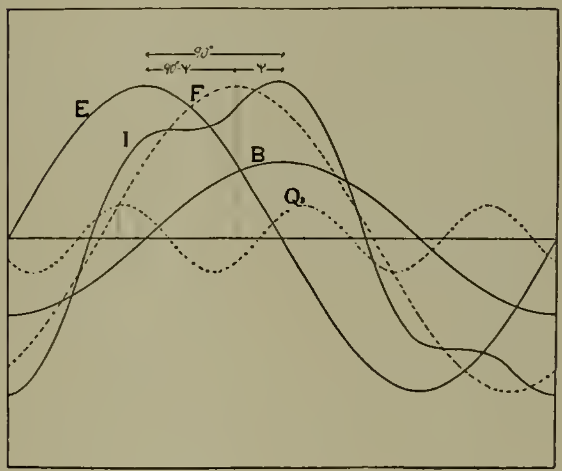


FIG. 2.—COMPLEX CURRENT I AND INDUCTION B, WITH MAXIMUM VALUES 90 DEGREES BEHIND SINUSOIDAL ELECTROMOTIVE FORCE WHEN IRON IS PRESENT. THE FUNDAMENTAL SINE CURVE F LAGS 90—ψ DEGREES BEHIND E

but distorted, as in Fig. 2. Since B and H are no longer proportional, instead of a straight line we have the hysteresis loop representing their cyclic operation.

The authors dealt with the fundamental and third harmonic only. Definite relative amplitudes and phase positions were successively assumed for these, and the complex current waves built up. From this complex wave of current and the sine wave of flux, the hysteresis loop which would cause such a current was determined.

The equation for the current is

$$i = \sin wt + \beta \sin (3wt + \Theta).$$

The amplitude of the third harmonic is β (taking the fundamental as unity) and Θ is its phase-angle, $+\Theta$ indicating an advance, and $-\Theta$ a lagging of the origin of the harmonic relatively to the origin of the fundamental.

Let us take a typical case represented in Fig. 2. The assumed fundamental and third harmonic of the current are represented by dotted curves. Here the amplitude of the harmonic is taken to be $\beta = 0.22$ (the amplitude of the fundamental being unity) and Θ is taken to be $+45$ degrees. The maximum of the current wave necessarily coincides in time with the maximum of the induction (for in a hysteresis loop the maximum H coincides with the maximum B).

The sinusoidal flux, in accordance with Faraday's law, is 90 degrees behind the sinusoidal electromotive force; accordingly, the maximum of the induction and hence of the current is 90 degrees behind the electromotive force. It will be noted, however, that the fundamental of the current wave has its maximum in advance of the maximum of the complex wave by an angle ψ, the hysteretic angle of advance, in this case equal to 9 degrees 23 minutes. The fundamental current wave lags then 90 degrees — ψ behind the electromotive force and represents power consumed by hysteresis, with a power factor cos (90 degrees — ψ) $= \sin \psi$.

If Θ, the phase-angle of the harmonic, is between 0 degree and 180 degrees, we find that the right-hand side of the complex current wave will have a hump, as in Fig. 2. The fundamental will be advanced to the left so as to lag less than 90 degrees behind the electromotive force, representing power taken by hysteresis,—a possible case.

If, however, Θ is between 180 degrees and 360 degrees; that is, if the harmonic is made to be behind instead of in advance of the fundamental, the hump on the current curve will be found on the left, and the fundamental will be shifted to the right so as to lag more than 90 degrees behind the electromotive force, representing power given out by hysteresis,—an impossible case. In this case the hysteresis loop must needs be traversed in the reverse direction from the actual counterclockwise direction and its area would represent work given out per cycle. Fig. 2 turned upside down would represent such a case.

The method of obtaining the hysteresis loop was described as follows:—A hysteresis loop consists in plotting corresponding values of B

and H in rectangular co-ordinates. A hysteresis loop corresponding to the curves of Fig. 2 is accordingly readily plotted. H is directly proportional to I, and hence the curve for I may be taken as a curve for H. Corresponding values of H and B are taken directly from the curves in Fig. 2 and plotted in rectangular co-ordinates to give the hysteresis loop of Fig. 3.

The interpretation is this: we arbitrarily assume a complex current I, made up of a fundamental and third harmonic, Fig. 2. The sinusoidal induction B and electromotive force will then be as shown in Fig. 2. The hysteresis loop which would produce the assumed distortion is shown in Fig. 3.

When $\Theta = 0$ degree, or 180 degrees, the hysteresis loop becomes a curved line; the ascending and descending curves coincide and enclose no area, representing, therefore, no hysteresis loss, although the permeability varies. They are impossible limiting cases; the angle Θ must accordingly be more than 0 degree and less than 180 degrees, and positive.

The hysteresis loops derived in the paper from consideration of the fundamental and third harmonic only in the current wave, had an unnatural appearance, particularly near the maximum values. Hence it was concluded that the fifth and other higher harmonics are necessary in the complex wave in order to derive therefrom a more normal hysteresis loop, particularly when saturation in the iron is passed.

A table was given, showing the limiting values of the amplitude of the harmonic and the hysteretic angle of advance for various values of θ. The complex current curve, fundamental and third harmonic for various values of θ were also given, with corresponding hysteresis loops.

It was sought to derive an expression showing the relation between the area of the hysteresis loop and the angle of hysteretic advance. A vector representation of complex current was also given.

DISCUSSION

In discussing the paper, Dr. Steinmetz said that the paper was rather theoretical, and while of scientific interest, appeared rather of little practical value to the electrical engineer. There is, however, to-day only a very short step between pure scientific investigation and engineering practice, and he hoped to show that the phenomenon dealt with in the paper and similar phenomena are of very great practical importance in alternating-current distribution; that is, wave shape distortion may lead to effects not only very marked and pronounced, but occasionally disastrous.

Now, in general, in investigating the effect of iron in alternating-current ciruicts, the curve of exciting current is produced and calculated from the hysteresis side of the iron. Dr. Bedell proceeded in the inverse manner, by superimposing different characteristics of current, and from these complex currents produced a hysteresis loop, and, seeing whether the hysteresis loop is a reasonable one or not, derived therefrom relations regarding the relative intensity and phase of the triple harmonic and also the wave of the exciting current.

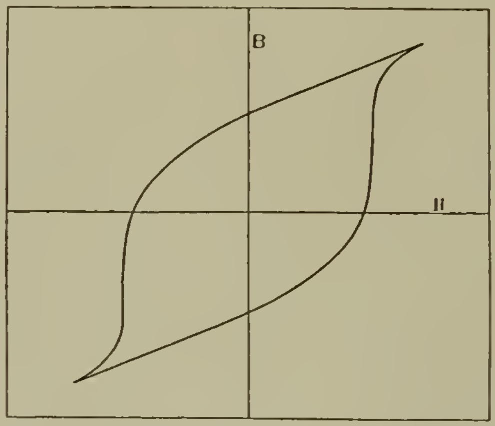


FIG. 3.—HYSTERESIS LOOP CORRESPONDING TO FIG. 2

As far as the investigation goes, it extended only to the fundamental and triple harmonic, and the investigation of higher harmonics is left to a future occasion. The higher harmonics are necessarily modified to a certain extent by assuming merely the fundamental and triple harmonic as present. For instance, by taking the fundamental wave and a triple harmonic, and superimposing the two waves, a wave is obtained with a hump on the rising side and the hollow on the decreasing side. If one goes further and deduces a triple harmonic of higher amplitude, the hump develops into a double peak.

Now, it is obvious that the double peak cannot exist, because different relations may exist between magnetism and the magnetising current; the current must rise as long as the magnetism rises, and cannot fall, hence the curve must steadily rise.

Sometime in 1881 or 1882 Dr. Froehlich noticed that the magnetic characteristic of the dynamo machine would be properly represented by a parabolic curve. Dr. Kennelly showed that the B and H curve, the magnetic characteristic of iron, would be epressed by a parabolic curve. The equation of a parabola for the relation between B and H would be found by applying a strictly mathematical curve, which combining with the sine wave, the latter representing the hysteresis loss, would fairly closely represent the distorted wave, or exciting loss.

In dealing with hysteresis, we have to keep in mind the difference between magnetic hysteresis and the energy lost in the iron. Now, if iron is exposed to the alternating magnetic field, the loss that takes place, the loss of energy in the iron by some form of magnetic friction, that loss is usually expressed as molecular magnetic friction. This loss seems to be constant, independent of the frequency of wave shape, but depending only on the maximum values of the magnetic induction which takes place. If the electrical circuit, traversed by the alternating current, is the only source of power, and no power is consumed outside of the iron, then the energy or power consumed by molecular magnetic friction must be supplied by the alternating circuit and supplied in the form of a hysteresis, and in this case molecular magnetic friction and magnetic hysteresis coincide, or rather magnetic hysteresis measures the molecular magnetic friction.

As soon, however, as there is another source of power present, and power can be consumed elsewhere, this coincidence disappears and has no inherent relation between molecular magnetic friction and magnetic hysteresis. Where there are less laminations in the transformer, it will be found that the electric circuit in the form of hysteresis loss supplies more energy than contained in the iron or molecular magnetic friction. The difference is consumed in the vibration of the laminations, in making noise. Where there is energy supplied from an outside source, this may go so far as not only to make the hysteresis load disappear, but to make it negative.

Interesting conditions where the hysteresis loop could be flattened out or turned over were investigated by Mr. Eickmeyer and Dr. Steinmetz in 1891 or 1892. It was found that when running at synchronism that such an arrangement can give all kinds of hysteresis loss; for instance, it is found from such a relation that the more the motor is loaded, the flatter becomes the hysteresis loop; when the friction is supplied by an outside source the hysteresis loop collapses.

To show the bearing the discussion had on practical engineering, the speaker took the case of three transformers connected in star or Y. Consider the three electromotive forces as E-1, E-2 and E-3, 120 degrees apart. Assuming the impressed electromotive force to be a sine wave. Now if E-1, E-2 and E-3 are all sine waves, they would usually have the shape of the exciting current that is contained in certain harmonics.

These three electromotive forces and the other currents are 120 degrees apart. The triple harmonics and the current are, therefore, three times 120 degrees, or 360 degrees apart. These triple harmonics cannot flow, because they have no circuit; in other words, there would be no triple harmonics or current in the case of Y-connected transformers.

In this system each transformer has an electromotive force higher than the size of the triple harmonic. In cases where the neutral is not grounded, these harmonics or electromotive forces are all three in phase with each other. The electromotive forces being in phase with each other means that there is from a neutral toward the ground a potential difference of double frequency, which is the triple harmonic created by the hysteresis. The neutral of the Y-connected three-phase transformers differs in potential from the ground, by the electromotive force of a certain frequency which is generated by the hysteresis distortion in the transformer.

Now, assuming that the neutral is connected to ground, for obvious reasons the electromotive force between neutral and ground will disappear. The triple harmonic or current still cannot flow if only one side of the transformer is grounded. That means there is a potential difference in the three transformers, still containing a certain harmonic, and all these triple harmonics being in phase to each other means that all three lines rise and fall simultaneously in synchronism with each other against the ground, or a triple frequency forms between three lines of the three-phase system and the ground, which may have a fairly considerable magnitude.

Suppose the transformer feeds into a long-distance system, the neutral being grounded; the transformer connected to the three lines will have capacity against ground represented by three condensers. There are now triple frequencies generated in their coils in phase with each other. From the neutral through the three transformers in multiple, triple frequency is obtained in series with inductance and capacity.

Such a combination may be very serious in certain circuits with destructive voltage. It is the voltages of triple frequency which are generated by hysteretic distortion, but even if they are not serious, the rise and fall of the whole system at every frequency means electrostatic induction on neighbouring circuits, and current will be induced on the circuit electrostatically.

Suppose a transformer has the neutral grounded; that means that the triple frequency current flows over the ground, and we have now in the system a triple frequency current which flows over all three lines in parallel and back over the ground; and while you do not get any more electrostatic induction, you get electrodynamic induction.

The existence of the triple frequency or distortion of the hysteresis wave may result in distortion of neutral or ground, or may result in electrostatic voltages or triple frequency inside the system, being liable to cause destructive surges and result in triple frequency currents, causing electromagnetic disturbances.

If we have a three-phase generator with the three coils Y-connected, if there is a triple frequency electromotive force in each phase, these electromotive forces are in series, short-circuited upon themselves, in the three-phase, delta-connected generator. There is, however, a very essential difference between this case and the corresponding case of the transformer. In that case it can only be the triple frequency component of the exciting current. Here in the generator it is a short-circuit current of the induced electromotive force of triple frequency. Such a current wave was observed years ago. It may in many cases be the cause of abnormally great hysteresis losses which have escaped attention.

In the case of the Y-connected generator, the same thing is found,—the three electromotive forces are all in phase with each other. The neutral against ground has a triple harmonic, and if we do not get a path for this triple harmonic, we may get currents which, in this case, are not merely 2 or 3 per cent. of the full load current, which represents the frequency component of the existing current, but may be full load current or more.

If the phase relation of the triple frequency harmonic with the fundamental is the same, there would be no current in the neutral, but if now we run two machines at different excitation, exciting one higher and the other lower, there will flow between the two machines a wattless current magnetizing the under-excited and demagnetizing the over-excited machine.

The triple frequency current may reach very serious values and become very considerable. If we have two generators, one having a triple frequency, the other not, the same phenomena is obtained of the triple frequency of the electromotive force of the neutral, resulting in the triple frequency current, but the current is not limited, and may occasionally reach values comparatively high, and that is why it is not safe to freely ground the generator. If the generators are grounded they should be grounded at a safe distance, or if they get grounded or connected with each other, it means they must have exactly the same wave shape and the excitation kept very close in each generator.

In continuing the discussion, Prof. W. S. Franklin said that as to the assumption which is made in all alternating-current treatises that currents generated by alternators are harmonic, it seemed to him a false idea which many people had gotten into, for the reason that if an alternator develops an e. m. f. of any complicated wave shape whatever, the problem often arises to determine the current produced by the e. m. f.

That problem mathematically resolves itself into a series of problems, each one of which is an ordinary simple alternating-current problem. The first thing is to resolve the matter into harmonics, and then treat each harmonic electromotive force by itself, and discuss the currents produced, and if the currents are distorted they must be analyzed and handled in an elementary way. That is the theory of alternating currents based on harmonics.

In regard to the matter of the magnetizing current, he called attention to one feature, and that was, in speaking of the angle of hysteretic advance, two meanings were attached to it, one by Mr. Bedell and one by Dr. Steinmetz. He did not think it important that they should be uniform, because we do not use them very much. He thought the best meaning of that expression is that which brings it into closest connection with what is measured on an alternating-current circuit by ammeters, voltmeters and wattmeters.

Whenever an ammeter is placed on a loaded transformer the effective value of the alternating current is measured. In speaking of the equivalent sine wave of harmonic current, which is the equivalent of the magnetizing current, it should be understood that they must be one and the same effective value. The equivalent magnetizing current should be one which takes the same power from the supply mains as the actual harmonics; therefore, we ought to define harmonic magnetizing current as the one which takes the actual power from the main as taken through the transformer.

Now, if we define the equivalent harmonic magnetizing current in that way, the angle of hysteretic advance is simply the difference between that current and the flux of the current. The speaker thought that in definitions of equivalent sine waves and equivalent sine currents it should be kept in mind that experience teaches us that we should bring our definitions into as close connection as possible with ammeters, voltmeters and wattmeters. We are much inclined to analyze things theoretically into numbers or parts that cannot be measured.

In regard to the matter of representing alternating electromotive force and currents in diagrams, Prof. Franklin called attention to two distinct ideas which are involved in that representation. In teaching students, he had, perhaps, made a mistake in using the vector diagram, not to represent effective values or anything of the kind, but to give a picture of the actual successive and instantaneous values of harmonic electromotive force or current.

The shape of the vector diagram which seemed to be in Mr. Bedell's mind gave a picture of the alternating-current simply because it is found that a current of fundamental frequency, and a current of triple frequency, when superimposed, give an effective current which is equal to the three, and in order to give a geometrical picture of the diagram Prof. Bedell chose to represent the triple harmonic. We must, however, keep clearly in mind that we are using the vector diagram merely as a geometrical picture of a formula, but not to represent to the student's mind the actual physical things which take place in the circuit. We should limit the vector diagram as much as possible to representation of physical effects.

Dr. Steinmetz referred to the work done a number of years ago by Prof. Froehlich. Prof. Franklin thought that physical science has advanced to a point where we should drop the principles which prevailed in Keppler's time. Keppler, in discovering the laws of planetary motion, simply took all the available data and tried every conceivable equation and form of curve until he found an elliptical loop.

What the speaker had in mind was that engineers, especially, ought to recognize that there are certain things which are not amenable to mathematical formula. He was convinced that certain phenomena in Nature cannot be formulated mathematically. He did not think there was any mathematical equation of hysteresis. If that was true, why should we have in mind the idea that there is, away back in some place, a mathematical formula or some brief curve which will fit that case and go hunting for it when there is no possible way of finding anything which really and actually represents the facts?

We should recognize the fact that we have reached a point where we can see that certain phenomena cannot be represented by rigorous formulæ, and we should drop the formulæ, equations and great mass of data which we find relating to those things. The speaker did not mean that an approximate formula was not of value and use, in tabulating a series of data, such as the coefficient of friction. The values may be tabulated or the curve plotted. The theory of probabilities can then be applied and the curve found representing all of them as nearly as possible. Let us not, however, fall into the error of thinking that there is actually a lot of value which stands behind that curve.

Speaking on the effect of vibration upon the magnetism curve, Prof. Franklin said that a number of years ago he conceived the idea that when a piece of iron was magnetized, after the magnetism curve was carried up to a certain point, a certain amount of the work put into the iron was already converted into heat, and a certain amount of work put into the iron actually existed in the iron as magnetic energy; that is to say, although we cannot separate the amount converted into heat, still there is a perfectly definite amount of work that has already been converted into heat, even after starting at zero and going up to a certain point on the curve. Now, if that is the case, there must be a potential associated with that magnetic energy, and that potential will show itself as demagnetizing energy.

Philip Torchio then asked a question of Dr. Steinmetz, in connection with the statement made about the harmonic short circuit, when a three-phase generator is Y-connected to the grounded neutral. In New York one of the largest companies tried at the start to operate all the generators steam driven with the grounded neutral, and they found a large short-circuit current on the neutral which was evidently due, as explained by Dr. Steinmetz, to the third harmonic. In another plant operating turbine-driven generators, or rather, two plants operating exclusively steam-turbine-driven generators, no short-circuit current of the neutral has been demonstrated by the ammeter; that is, the neutrals of the Y-connected generators were dead grounded, still no cross current appears on the ammeter. Would Dr. Steinmetz explain why the steam-drived generator gave the third harmonic short-circuited current, while the turbine-driven generator did not give such a current?

In answering, Dr. Steinmetz said that the turbine generators were all alike, running with identical wave shapes at equal excitation. He did not know what station was referred to, but thought that in the same station some steam turbine generators were afterward installed, and between the old ones and the new ones they got short-circuits from the neutral. It is a question whether the triple harmonics are identical and have the same phase, or whether they are not identical and have not the same phase.

In closing the discussion on his paper, Mr. Bedell said that Prof. Franklin's remarks were, in general, fully in accord with his own views. Prof. Franklin had also emphasized the authors' views in regard to the significance of the geometrical construction. It was merely a picture which helped one to understand some relations, relations which are obtained in the diagram, but the diagram is not in any wise a physical representation of the facts. He furthermore emphasized the fact that it is useless to attempt to adopt rational formula to perfectly represent certain relations.

THE CURRENT TRANSFORMER

The paper on "The Current Transformer," by K. L. Curtis, was read by H. S. McAllister. This type of transformer, although mentioned but briefly in electrical literature, is one of the most indispensable of meter auxiliaries. By means of it currents of any magnitude may be measured with accuracy with the smallest of instruments. It enables us to use ammeters and wattmeters in circuits of the highest voltages. By the use of current transformers of different ratios we can use meters of the same size and capacity in circuits of widely varying power and voltage, thereby greatly facilitating the calibration and maintenance of the instruments. The use of transformers in connection with alternating-current ammeters and wattmeters is absolutely necessary in either of the following cases: first, when the voltage of the circuit is so high as to render it unsafe to connect the instrument directly into the circuit; secondly, when the current to be measured is greater than the capacity of the instrument, and conditions prevent the use of a shunt.

In the first instance the transformer insulation is made sufficient to protect the instrument from the high-voltage circuit. In the second case the ratio of turns is made such that the current through the instrument is within its capacity. In nearly all cases of alternating-current measurements one or both of these conditions are met with.

The current transformer, like all other transformers, consists of an iron magnetic circuit interlinked with two electric circuits. The primary is connected in series with the line, the current of which is to be measured, and the secondary is connected to the instrument terminals by leads of low resistance. With these connections it is evident that the meter-reading will go up and down with the line current; and although the ratio of the meter reading to the line current may not be the same at all times, any one value of the current will always give the same meter-reading.

If the instrument were in all cases calibrated in conjunction with the current transformer with which it is to be used, the only points necessary to consider in the design of the transformer would be the heating and insulating. In well-designed current transformers, however, the ratio of primary to secondary current is nearly constant for all loads within desired limits, so it is not necessary to test the instrument with its own transformer, except when it is to be used for refined measurements.

In order to predetermine the behaviour of a transformer, it is, in general, necessary to know: first, the resistances and reactances of the primary and secondary windings of the transformer and of the eternal secondary or load circuit; secondly, the amount and power factor of the exciting current at the various operating flux densities in the transformer core.

In the case of the current transformer, while it is desirable to keep the primary resistance and reactance as low as possible to prevent undue loss of energy, the behaviour of the transformer is not affected by their magnitude, as the secondary current depends only on the ampere-turns supplied to the core of the transformer by the primary winding.

The author then proceeded to discuss the transformer mathematically, and, taking one of the present commercial types, computed its ratio.

DISCUSSION

Following the reading of the paper, L. T. Robinson, of the General Electric Company, said that the subject of current transformers was of considerable interest to him at the present time because they had been doing some work along this same line, using a somewhat different method from that given by the author of the paper; that is, instead of determining the exciting current and the internal losses in the transformer by means of the galvanometer, by means of sensitive alternating dynamos these values were determined directly. They had been able to get a good agreement between the calculated values and the observed values. In connection with this the effect of wave distortion also was quite a prominent feature.

In making these measurements, if the resistance is included in series with the primary of these transformers, the impressed electromotive force on the transformer itself is distorted, the current wave is distorted, and it is rather difficult to determine, not what the exciting current is, but just what it would be under the conditions of use. Bearing on the question as to the extent such things affect actual results, he had some measurements showing that, even with the small losses which these delicate instruments have, in comparison with the losses in the transformer, which are very small, they are appreciable, although not to the extent that they destroy the value of the measurements altogether.

He had also taken under the same conditions several records of the distorted wave, which might be of interest both in connection with the paper on transformers and with the discussion on the sinusoidal wave which had also taken place. In connection with this subject, the phase angle between the primary and secondary currents is, in some cases, of more importance than the ratio of the currents, and especially when wattmeters are to be used and the power factors of the circuits to be tested are low.

Good results had also been obtained by determining with considerable accuracy the ratio of currents and then deducting from this ratio of currents and the phase angle between the primary and secondary, the existing current. It was found that this could be made to correspond within reasonable limits with the exciting current determined by dynamometer instruments and by the hysteresis.

A Telharmonium Concert

At the September meeting of the New York Electrical Society, held in the Cahill auditorium at Broadway and Thirty-ninth street, the members and their friends enjoyed a concert of electrical music produced by Dr. Cahill's telharmonium, or dynamophone, as it is also called.

Prior to the concert, the generating plant in the basement was open to inspection. The apparatus consists essentially of inductor alternators producing currents of different frequencies, which when passed through telephone receivers produce tones of different pitch. On a switchboard a large number of switches are provided which are operated from a keyboard on which the performers play in the auditorium.

A large number of adjusting coils, with transformers and expression devices of various kinds, are provided to enable the performer to give expression to his playing. When the performer puts down a key on the keyboard, a power switch on the switchboard is automatically closed, throwing the electric vibrations corresponding to the pitch of the tone required upon the line. Before they reach the line these vibrations pass through devices by which their power is controlled instantly and with the utmost delicacy, so that any effect, from the softest to the loudest and most rousing, is produced in perfect sympathy with the performer's feeling.

A simple wave from one generator may also be passed through the transformer, which will combine it with numerous other waves from other generators, whose frequencies of vibrations are of the harmonic series, thus producing a resultant electric wave corresponding to a musical sound. In other transformers various of these complex waves are combined into still more complex waves or vibrations corresponding to rich chords, and in still other transformers these complex vibrations of the second order are again combined into other very complex vibrations which represent various voices, a violin and 'cello, flute and piano, etc.

These vibrations are then distributed like electric light to various mains leading to different parts of the city. Translating devices, on the premises of the subscriber, are connected across these mains, translating the electric vibrations into aerial vibrations of exactly similar shape, frequency, power, etc., thus producing precisely the musical effect desired.

President Condict introduced Mr. Oscar T. Crosby, manager of the New York installation, who described the operation of the various parts. The present installation, he said, had a capacity sufficient to supply 15,000 or 20,000 outlets.

Other keyboards were to be installed, each one being devoted to a different class of music. Rag-time might be produced on one circuit, Wagner's compositions on another, and those of Chopin on a third. It was also feasible to install private plants, which, while apt to be expensive at first, would in a few years be sold at about the price of a high-grade piano.

The auditorium was provided with eight outlets and to these were attached telephone receivers equipped with megaphones concealed in baskets of ferns, hydrangea bushes, and at various points about the auditorium. A staff of musicians rendered several numbers, the program consisting of solos and duets. Vocal selections by Miss Fiske also were accompanied on the telharmonium.

The work of installing separate telephone cables is now under way in the conduits on Broadway over which the music of the telharmonium is to be distributed to subscribers. It is believed that the arrangements for this distribution will be completed by the end of October.

Electric vs. Compressed Air Rock Drills

MUCH has been written in the technical press of late regarding the relative merits of electric rock drills and those operated by compressed air. What appears to be a conclusive argument in favour of one type of electric drill, under certain conditions at least, is given in a letter to "The Engineering and Mining Journal," by C. A. Chase, general superintendent of the Liberty Gold Mining Company, of Telluride, Col.

Mr. Chase writes, in part, as follows:—

"The fact of the presence of electric power in the mine prompted the hope that we might use electric machines, thus securing the advantage of low construction cost as well as the greater saving in operation. At the end of one year's agony, during which we had tried three of the types of machines then offered, we were forced to abandon the experiment. A good motor-driven air plant, with 3¼-inch auxiliary-valve machines, finished the work effectively and at an ultimate saving in cost, by reason of the absolute regularity of the work.

"These results were not such as to build faith in electric machines, but in 1904 our attention was called to the new Temple electric air drill, and the third Temple machine was sent to us for trial. Our opportunities for comparative tests were excellent, as we still had 3¼-inch air machines working at 100 pounds pressure in the country rock of andesitic breccia, and placed the new machine on similar work.

"Day by day the Temple machines would drill as fast, or faster, than the other machines. The common shift's work was established at 50 to 60 feet of hole drilled, loaded and shot by the machine runners in eight to nine hours as against a similar footage drilled, but not loaded or shot, by the men with the standard air machines.

"We purchased the machine without question at the end of an extended period of trial, and to-day, after nearly two years' service, it is still at work. It is now in use by contractors on drift work on the vein. That the machine is acceptable to contractors is, in itself, a very strong indorsement.

"This machine operates on direct current, and this involves the interpolation of a rotary transformer, which is objectionable. Since its installation we have also bought the first Temple machine to be sent out equipped with a 400-volt, three-phase, alternating-current motor. This machine has two speeds, and since the perfecting of the switch has given excellent results.

"There have been delays in the operation of the machines, but they have been from the fact that, on a machine so new, sufficient information had not been compiled. Of late months these delays have been at a minimum. The cost of repairs has been hardly more than on the standard machines.

"The power consumption is 5 H. P. per drill. At our altitude, running only a two-drill compressed-air plant, we found our motor input at the compressor to be 50 H. P. Inasmuch as we buy power on a peak-load contract, the difference is obvious.

"For any man to pose as an advocate of either electric power or air power solely for mining use, seems to me quite futile. Since we have adopted the Temple electric machines for drifting, we have found economy in the introduction of small air hammer machines (Leyner) for stoping and raising. We still find occasional use for the standard air-machine. In the meantime, we hoist timber into all stopes with portable electric hoists.

"To my mind, there is a place for electric drills in many mines, and certainly we have found one drill that can fill the place here. That other drills may have been perfected is possible; but I desire to discuss only what I know, so we will leave the other drills for other men who may know."

Standard Symbols for Wiring Plans

A REPORT on uniform symbols for wiring plans was recently submitted to the National Electrical Contractors' Association by a committee, consisting of G. M. Sanborn, E. S. Keefer, and J. K. How, appointed at the fifth annual convention at Boston in 1905.

The committee, desiring to obtain an expression as to the advisability of establishing a uniform set of symbols and the best and most feasible methods of having the same universally used, addressed letters to the leading engineers, architects, universities, various departments of the government, and the technical press. The replies to these letters were unanimously in favor of establishing uniform symbols, and the writers tendered their assistance and co-operation in the movement, and offered for the use of the committee the symbols in use in their offices.

The committee made a careful study of all the letters and systems submitted to them, desiring to develop a set of symbols that would conform as closely as possible to the different ones now in use. They selected from the many valuable suggestions those which appeared the simplest in form and the easiest of execution, and added to them such others as seemed necessary to make the system complete.

Each symbol has been given careful study, and while the committee appreciates that the subject gives ample opportunity for many individual ideas, they believe that considered as a whole the symbols will be found to cover all the conditions and requirements of complete wiring plans.

A copy of the symbols may be had by addressing the secretary, W. H. Morton, 94 Genesee st., Utica, N. Y.

Adjuncts to the Power Load

By C. J. RUSSELL, of the Philadelphia Electric Company

A Paper Read at the Recent Convention of the Association of Edison Illuminating Companies

CENTRAL station development of the electric power field has resulted in a marvelous growth in the sales of electric energy for transformation into mechanical energy. The electric motor has invaded branch after branch of manufacturing industries, and data of actual installations operating almost every known form of machinery are now available for the use of the central station manager and his prospective customers.

The sales of electric current for transformation into luminous and kinetic energy may be said to be proceeding along well-defined and satisfactory lines. Progress has called forth progress, in the one case of new illuminants and accessories, in the other of special applications and improved methods.

To broaden the field of sales it is but natural that central station interests should turn to the two remaining transformations of the electric currents, namely, into caloric and chemical energy. In the first named of these transformations the central station has met with much encouragement. The introduction of domestic and industrial heating appliances has at least blazed a trail into the undeveloped country.

Viewed from the standpoint of comparison with the early experiences in the lighting and power fields, the results are certainly satisfactory. It has been clearly proved that there is a great opening for sales of current for electric heating in cases where the specific advantages of flexibility, ready control, high temperature and direct application can be made to count.

For industrial use electric heating may be said to present, over other methods of heating, all the advantages of the electric motor over other forms of motive power. Its use permits individual equipment, the concentration of intense power without the conduction of dangerous or explosive mediums, and without the losses incident to such conduction. The other advantages of cleanliness, absence of vitiation of atmosphere, etc., are too well proved by existing devices to require comment here.

In industrial operations the supply of electric current for heating is intimately related to the supply of power, as its greatest use will be in establishments using power machinery. The hours of its use will be practically the same as those of the industrial motor. These facts entitle this class of business to the same treatment in the matter of rates as the electric power business, and it may properly be classed as an adjunct to the power load.

The development of the electric heating business may be expected to follow the ordinary economical laws of demand and supply. The demand may be separated into two distinct classes: first, created demand, as in those cases where new processes or products may make possible the establishment of new industries; second, existing demand, as in those cases where present methods may be superseded by electric methods with the result of increased and more perfect output. The supply rests with the inventor and electric heating engineer, who must perfect new processes to create demand and devise improved appliances to fill the existing demand.

It may be argued that we have little to do with the first class. As a matter of fact, we may do much by offering attractive rates and by giving our encouragement to such pioneer work in every possible way. In the second class we are undoubtedly a potential factor. Just as the central station has been the greatest selling power in the lines of lighting and motor appliances, so can it become the greatest advocate of the use of electric heating for industrial purposes.

Our business brings us into intimate relations with the possible users of such devices. To many of them we stand in the position of consulting engineers, and the power of our suggestion as to anything relating to their product or processes cannot be denied.

We serve printing establishments to which the value of electric heating appliances for linotype or monotype machines and all the operations of the stereotype rooms cannot be overestimated. Some of these establishments do binding, and to them the application of electric heat to press heads, shaping machines, gluing processes, etc., would prove great money savers.

We serve laundries to which electrically heated machines would bring the same advantages as the domestic iron has brought to the residence. The metal industries on our systems may find in the electric welding machine and in the electric furnace just what they need in the way of improved equipment.

Textile mills have numerous process requirements which only need the application of electric heat to produce improved results. Whether it be the humble soldering iron, the glue kettle or the electric furnace, every application of electric heating devices will help to conquer this field for the central station, and the placing of the appliance is worthy of earnest effort.

If the central station has proved itself a potent selling agent in other fields, it has done so by campaigns of education, and in the newer fields this experience will undoubtedly be repeated. Proved appliances must form the foundation for attack upon any such proposition, and our equipment in this direction is such as to encourage the central station manager.

The minor appliances are well known, such as soldering irons, glue heaters, special irons for the hat factory, warming pans and stoves for miscellaneous and special uses. The special applications for the binding and stereotype trades may not be so well known, but they have been well tried out, have proved very satisfactory, and data regarding their operation are readily available to those interested. The recent types of laundry application are also giving very good satisfaction.

The data obtainable upon the operation of the various classes of machinery mentioned would seem to prove that the cost of heating becomes insignificant in the face of the

FIG. I.—AN ELECTRIC STEEL FURNACE OPERATED ON CENTRAL STATION CURRENT. IT IS OF THE INDUCTION TYPE AND OF 131-KILOVOLT-AMPERE CAPACITY. SINGLE-PHASE, 60-CYCLE CURRENT IS SUPPLIED AT 240 VOLTS

greatly increased and improved output made possible by the use of electricity. In this, as in the power field, the decreased cost per unit for each perfect article produced controls the situation and may render the new method preferable at double the cost for energy alone.

ELECTRIC WELDING AND TEMPERING

The field for electric welding and tempering is unquestionably a large one, but machines for this purpose have not been as generally introduced as the publicity given to this class of apparatus and the remarkable results accomplished by its use would lead one to anticipate. It is also to be regretted that the method of installation generally urged and adopted has been in connection with a special generating equipment.

In the sizes up to 30 KW. no valid reason can be presented for the installation of a special generator. We have several outfits on our system ranging from 15 to 30 KW. capacity, and their effect is not greater than that of a motor of similar capacity.

The load factor of these outfits is low, averaging three hours. The reason for this is understood when we consider that the longest period of welding in average work will not exceed 40 seconds, whereas the operation of adjusting and removing the work may occupy three to four times this length of time.

Proper presentation of the advantages of these outfits to accomplish specific results in large manufacturing establishments making metal articles of special shape should result in their more general use. There would also appear to be room in each large city for a jobbing shop to handle the work for smaller concerns which could hardly afford to make individual installations on account of the royalties charged upon the machines of a fixed sum per annum.

Suggestion of the use of a welding machine was made some time ago to one of our large power consumers under the following circumstances:—In passing strips of expensive rolled metal between dies it was necessary to rivet succeeding strips together in order to allow continuous operation. When this riveted portion came along it was necessary to open the dies, resulting in quite a loss of the rolled metal. The welder was introduced and now makes a butt weld on these strips, the fin or burr being removed by an emery wheel on a flexible shaft. The dies can operate continuously, and the saving is from 5 to 8 per cent. of the total length of metal worked.

In another case where thin discs of rolled, spun or hammered metal developed a defect at one portion of the rim, the almost completed article had to be thrown into the scrap pile. A welding machine is now used to weld a piece of metal on at the place of the defect, which is sheared off, and, after completion, it is impossible to detect the place where the joint was made.

In another case where repairs to

costly pieces of large size constantly required careful soldering and refinishing, a welder was installed with the result of reducing the time consumed in these repairs to one-sixth that formerly necessary. In this case certain articles were also manufactured requiring stamping from large sheets with much waste on account of their shape. The suggestion of welding these up from narrow strips was made, and a few samples prepared. Within thirty days after these went out to the trade the welding machine had a steady six-months' job on the books and our revenue increased from this source of current sales.

While most of the welding done is of the butt type, some special machines have been developed, one for making wire fencing and another for making longitudinal welds on pieces of large diameter, such as the joints in the shell of hot water boilers for domestic use.

The electric tempering process by use of the electric welding machine does not appear to have been developed to such an extent as its advantages would seem to merit. The heating of specially shaped pieces by the ordinary means is often accompanied by distortion, which is fatal to the article itself. When heated by the passage of an electric current this is not the case, and the tempering of such delicate articles as the rolls used for drawing cotton is successfully done by means of this process. The uniformity of the heat generated in this way in metal of small cross-section and the excellent tempering results obtained have proved eminently satisfactory in such special lines as have come under our observation.

ELECTRIC FURNACES

The importance attained by this class of apparatus entitles it to serious consideration from the central station standpoint. Foreign developments are attracting universal interest on this continent, and the next few years will probably witness extensive applications of the electric furnace in various industries on this side of the water.

The obtaining of commercial data upon the subjects of the electric furnace, its applications and products, is a somewhat difficult matter. The whole subject is surrounded with such mystery by those now using electric furnaces, and the data obtained are so incomplete and vary so widely, that the investigator may conclude that the apparatus is in a purely experimental stage.

The electric furnace has come to be regarded as one of the most important tools of the electrochemist, and is generally classified under that branch of science. Strictly speaking, it may be regarded as misplaced, since in itself it is simply a form of apparatus for the utilization of heat transformed from electrical energy. As from the present point of view, however, such furnaces will have principal use in industries dependent upon physical and chemical changes in their materials, the classification is probably both correct and proper.

From a commercial standpoint the electric furnace is a piece of apparatus for the generation and utilization of heat. The comparison between various types designed to accomplish specific results must proceed along these lines, as far as efficiency and economy are concerned.

The heat may be used to accomplish physical changes alone, or physical and chemical changes. In the latter case a certain proportion of the energy may be absorbed in the chemical reactions necessary, and it may be aided by the chemical reactions occurring during the operations. As the heat units actually utilized to accomplish given results can be readily calculated, the real efficiency of any process can be determined with accuracy.

The transformation of electric energy into heat energy by means of resistance may be utilized in an electric furnace directly or indirectly, according as the materials to be treated are or are not conducting. In the direct method the heat is generated within the material itself, which in this case is part of the circuit, current being led to it by suitable electrodes which are provided with means to prevent their fusion, such as water circulation; and in the direct induction furnaces the heating currents are generated within the materials themselves, constituting the secondary of a transformer circuit.

In the indirect method the heat is utilized by radiation or conduction. In the arc types, the resistance is gaseous and the arcs are formed between electrodes or between the electrodes and the materials to be treated, if they be conducting. These arcs may evidently be formed within or outside of the receptacles containing the materials to be treated, or the latter may be made to pass through the arcs while being fed into the receptacles.

In the solid resistance types, the heat may be generated within solid conductors contiguous to the mass to be treated. These conductors may be solid or molten at the temperature at which the furnace is run, may be arranged within the refractory walls of the receptacle, within the mass of the material itself, or may be superimposed upon the mass as in those processes utilizing heat generated within a slag resistance floating upon the bath to be treated.

FIG. 2.—THE CRUCIBLE OF THE ELECTRIC FURNACE SHOWN ON THE OPPOSITE PAGE

FIG. 3.—POURING MOLTEN STEEL FROM THE ELECTRIC FURNACE SHOWN IN FIG. 1.

Division and subdivision of these classes may be elaborated, but as efficiency must become an all-important factor in the ultimate development of the electric furnace, it is probable that the classification mentioned will be convenient for purposes of comparison.

The maximum temperatures attained in commercial furnaces range from 2000 degrees C. to 3500 degrees C., or from 3632 degrees F. to 6332 degrees F. The latter figure may be anticipated, since the latest determinations of the temperature of the arc approach 3700 degrees C., as given by the United States Bureau of Standards working with the Wanner, Holborn-Kurlbaum and Le Chatelier pyrometers.

An examination of the history of the development of the electric furnace is principally interesting from the early dates of disclosure of the vital principles of existing furnaces, and as showing that it was retarded only by the absence of suitable means for the generation or supply of the necessary amount of electrical energy.

The fundamental principles of existing furnaces were disclosed during the period from 1815 to 1887, and this fact, together with the extensive foreign applications of furnace methods, is worthy of consideration on the part of those having electrical energy for sale.

The tardy developments in this country have been due in a measure to the fact that the electric furnace man and the central station man did not get together. The industries require comparatively large quantities of electrical energy, and almost up to the present time it has been assumed that water-power alone could develop the current at a cost low enough to meet the requirements. Water-power within available transmission distances of large centres has been in demand for light and power plants, and power sites not so situated may lack the facilities of transportation and of ample supply of raw materials essential to the operation of electric furnace processes.

In foreign countries the decadence of the calcium carbide industry caused an active demand for processes to utilize installations completed and under way, with the result that with modified furnaces a large and constantly increasing output of various ferro-alloys has almost completely annihilated the old cupola processes and products. The use of these alloys in the iron and steel industry has called for rapid extensions of existing electric furnace plants, and it is at this time estimated that fully 100,000 horse-power is being utilized for this purpose alone.

From the production of ferro-alloys it would seem but a step to the production of steel. The step was taken and electric steel has been on the market in moderate supply for about five years.

Within the past six months considerable electric furnace work has been done in Philadelphia with current supplied from our generating stations. One installation is of especial interest as being the first to produce high-grade crucible steel upon a commercial scale on this side of the water, by heat from electrical energy.

The furnace is of the induction type, of 131 kilovolt-ampere capacity, and is supplied with single-phase, 60-cycle current at 240 volts. It is in principle a transformer, the secondary of which is constituted by a circular trough-shaped crucible and its contents. The primary consists of twenty-eight turns of copper tube, cooled by internal water circulation and insulated by sectional layers of heat-insulating materials.

The furnace is shown in Fig. 1, the crucible in Fig. 2, and the furnace tilted as in the operation of making a pour in Fig. 3.

The construction is simple and rugged, as can be readily seen from the illustrations. The transformer frame is mounted upon trunnions and fitted with gears and a hand wheel for convenience in tilting. The tap member, which is removable, is provided with cams at each end for the application of pressure to insure good magnetic contact, and the handles operating these cams can be seen in Fig. 1, lying parallel to and just above the top of the transformer frame. Bolted to each side of the lower part of the frame are brackets, upon which rests a circular piece of soapstone which serves as a foundation for the crucible. The top lid, or covering, of the crucible is made in sections for convenience in introducing materials and for observing the process.

The manipulation of the furnace is very simple. In starting operations, a cast ring may be placed in the crucible or a pot of melted metal poured in from another furnace and the current turned on. When this metal is at the proper temperature, the materials are added in the right proportion and the whole brought to the condition desired and an ingot is poured off.

When a pour is made, sufficient metal is left in the crucible to maintain the circuit and new materials are at once introduced. Charging is done gradually, in order to prevent freezing the mass. The fusion of the new charge ordinarily takes about thirty-six minutes, and the total time between pours is from an hour to seventy minutes, according to the character of steel to be made.

The secondary current is, at a maximum, 15,148 amperes at 8.57 volts. The current consumption varies with the percentage of carbon in the charge and finished steel, but it will average about 28 KW.-hours to melt and a total of 36 KW.-hours to a pour per hundred pounds of steel.

The temperature of the cooling water is raised only from 10 to 20 degrees from inlet to outlet, with a very moderate flow. The heat insulation of the crucible is so perfect that the outside of the casing is barely warm to the touch while the furnace is in full operation.

Starting cold, the power factor of the apparatus is rather low, but as soon as the metal in the crucible is heated to such a degree as to lose its magnetic qualities, it improves rapidly. When in full operation the power factor ranges from 93 to 97 per cent.

Careful observations of about sixty heats were taken with standardized instruments and much valuable data have been obtained. Several thousand pounds of each kind of high-grade steel of different composition used for cutting tools have been made in this furnace, and samples have been submitted to chemical and mechanical tests.

Since the heat is generated in the crucible without external contact or influence, it is obvious that the resultant product will be free from contamination other than that due to the materials themselves and to the lining of the crucible. For this reason the character of the steel can be absolutely predetermined.

The high temperatures attainable in the furnace render it possible to thoroughly remove all gases, and the steel is very fluid and still in the mould. The ingots are very dense and homogeneous, and tools made from them present a grain and silvery lustre unlike that of the ordinary crucible steel. The metal also has valuable characteristic qualities for the manufacture of high-grade tools requiring uniform temper. The results obtained have been so satisfactory that it is proposed to install a five-ton furnace calling for about 750-KW. current capacity.

The magnetic effect produces some difficulty in charging, but this is not serious when understood and properly avoided. It is evident that furnaces of this type can be readily designed for use on two or three-phase circuits. While no large furnaces of polyphase type have been manufactured in this country, two different forms have been brought out in France, one of which is much on the order of the one just described.

We also have on our system a furnace of 100-KW. capacity used for the smelting of special ore. This is of the combined direct and indirect type, arcs being used to start the process and the current being subsequently passed through the materials which are conducting when heated.

The work with this furnace has not reached such a point as to admit of more than a general reference to it. If as successful as the results abroad indicate, it is hoped that the preliminary work will result in a large installation with central station supply. There are also two smaller furnace equipments on our system, both used for tests in the smelting of various ores and for experimental purposes.

The electric furnace presents marked advantages over the old crucible methods. The first cost is from 20 to 25 per cent. of that of gas furnaces of similar capacity. There is no great mass of surrounding and containing materials to be heated to a temperature even higher than that necessary for the operations of fusion and refining.

Repairs of all kinds are cut down to a small figure. The expense of crucibles in the gas processes amounts to from $10 to $16 per ton of steel, as against $2 to $4 per ton with a built-up induction furnace. The cost of labour is radically reduced, and the discomforts of the old process are almost entirely done away with.

From these statements it will be seen that the cost of heat energy is not the only factor in considering the electric furnace as a substitute for existing appliances. Prominent metallurgists prophesy that the steel industry will be revolutionized by its introduction and that gas must give way to electricity.

While the central station may have no part in the large operations involving thousands of kilowatts of capacity, it would appear that there should be a good field for the supply of electric current for furnace purposes in relatively small plants requiring moderate quantities of special and high-grade steels.

ELECTROCHEMICAL PROCESSES

The subject of electrochemical processes is closely allied to the electric furnace and requires similar consideration.

Leaving aside, for the moment, the question of central station supply of electric current for the purpose of the manufacture of various chemical compounds on a large scale, there are many processes which are applicable on a moderate scale to several industries with which we come in contact in the light and power field.

The various compounds and solutions used for bleaching interest our textile customers. In certain lines the use of chlorine for this purpose is universal, and most of us are familiar with the disadvantages of the method of bleaching by the use of bleaching powder or chloride of lime.

By passing a current of electricity through a solution of common salt, sypochlorite of sodium, or electrochlorine, is obtained. In properly arranged apparatus no gas escapes, which is a point of vast importance to the manufacturer. The activity of nascent products is well known, and it can be readily understood that the work done in this manner is superior and much more permanent than that done by the older methods.

This process has been widely adopted abroad, where 2000 horsepower is used for this purpose in various establishments in a type of cell put out by the Siemens-Halske Company. It has also been adopted by several leading manufacturers in this country, and is highly recommended in the linen and cotton trades. The process is also applicable to the bleaching of fibres for paper, artificial silk, oils, etc.

Some work of this character has been done on our system, and a motor-generator outfit of 15-KW. capacity has been found ample for the satisfactory bleaching of a ton of fibre per day of ten hours.

The expansion of electric processes for bleaching, finishing and waterproofing fabrics will be an interesting subject to follow up for central stations desiring to sell current for electrolytic work.

Another promising outlet for the sale of current is the industrial application of ozone. Regarded as a rare product until recently, and its production as a laboratory experiment, several large establishments are now producing this powerful agent in large quantities for bleaching and purifying purposes.

The applications for this, Nature's own bleaching and sanitary agent, seem to be almost unlimited. Some of the most practical of its uses are in the bleaching of flour and starches of textile yarns and fabrics, of paper pulp intended for the higher grades of product, the refining of alcohol and spirituous liquors, the treatment of varnishes and oils and for the improvement and purification of water used for drinking or manufacturing.

The last-named application is the widest one, and here ozone has proved its superiority over all known methods. The purification and sterilization of water without destroying any of its natural qualities, without the addition of any chemical compound and at a minimum cost, is a subject that vitally interests all classes of industries and individuals.

A gramme of ozone may be obtained with the expenditure of about 60 watt-hours. Two hundred and fifty gallons of water of average river variety can be treated with this amount of ozone. Naturally, the amount of ozone required depends upon the number of colonies, or thousands of bacteria present in the water. With an average of 200 per ounce, none remain after the amount of treatment described. With 2000 to 4000 per ounce, from 3 to 30 remain if the process stop at this amount of ozonization.

The method of treatment consists in aërating the water with ozonized air in apparatus arranged to make the air thoroughly mix or come in contact with every part of the water.

The electrical apparatus for the treatment of the air consists of a step-up transformer delivering high-potential current at about 60,000 volts, to specially arranged discharge plates between which the air passes on its way from the pump which forces it through the water. The air may be dried by refrigeration or by passing it over chloride of calcium before it passes to the discharge chamber.

Two types of ozone generators have been used upon our system. In one the dielectric was of glass and the discharge plates in multiple, each provided with a high series resistance which permitted the cutting out of any which developed defects. In the other the discharge took place across air gaps, and a choke coil and condenser were provided to prevent the formation of an arc and to raise the secondary voltage.

It has been our privilege to witness many chemical and bacteriological tests of the results obtained in the purification of water, both by the Webster process, employing iron electrodes, and by the ozone process. The former is principally efficacious in practice by coagulation, and the water needs aëration afterwards. The latter process provides aëration, improves the quality of the water, and is, by microscopic observation, much like machine gun practice to the unfortunate bacteria.

One of the installations mentioned was put in for the purpose of improving spirituous liquors. The method of treatment is similar to the water purification process, and the object is to produce within a brief period all the qualities given by age to liquor of different sorts. With the expenditure of a few KW.-hours per barrel, very crude raw liquor can be made equal to that which has been aged in wood for several years.

The purification of water used in breweries, both for the brewing and for sterilizing receptacles for the product, should offer quite an extensive field for the exploitation of the ozone process.

Several municipal plants are using the ozone process of purifying water in Europe. Individual residence equipments have also been quite extensively introduced in European countries, and it may be interesting to note that portable outfits for the same purpose were used in the field during the Russo-Japanese war.

Specific details of the various existing electrochemical industries and applications would fill volumes. While undoubtedly in their infancy, it must be admitted that their future growth depends upon the supply of large quantities of electrical energy at reasonable rates.

Considerable discussion has taken place as to the desirability of this class of business to fill in the hours between peaks and thus to equalize the station load. In these discussions great importance has been attached to the alleged fact that such business need not cross the peak and could be supplied with large or small volumes of current, according to the capacity of generators in service and the amount of other load upon the system at a given time.

There is no question that such a class of business would enable a station to operate under ideal conditions. It is evident that the question, however, must be dealt with according to the exact conditions of capacity and load of each individual station contemplating such supply. General statements may lead to a serious misconception of the true possibilities in this direction.

The character of load diagrams of all central stations which have cultivated the electric power field have undergone a radical change. In such cases the old condition of morning and evening peaks which represented almost the total generated load has passed. In the present load diagrams the kilowatt area of such peaks as exist bear a much smaller ratio to the area of the daylight load.

An examination of some mixed load diagrams may help to draw some conclusions in this matter. Fig. 4 shows a load diagram of a small generating station on the highest day of 1905. Fig. 5 shows the load diagram of the same station on a day close to the shortest of the present year.

In the case of the first diagram the total kilowatt area was 23,540. In order to equalize the load to the maximum of 1643 KW. capacity, it would be necessary to utilize in the twenty-four hours 15,892 KW.-hours, and the time and rate at which this was available is shown in Fig. 6.

In the case of the shortest day the total kilowatt output is 19,040, and in order to attain the maximum use of 1643 KW. capacity we should have available a supply of 20,392 KW.-hours. The time and rate at which this was available is shown in Fig. 7.

An examination of Figs. 6 and 7 will show that an electrothermic or electrochemical process must be capable of wide ranges of current utilization in order to meet the requirements of equalizing the load upon the station. As a matter of fact, electrothermic processes require for their successful and economical operation nearly continuous supply. The initial operation of bringing the furnace and materials up to the proper working temperatures may involve three times the energy required for their operation thereafter. Not only is this true, but the chilling and reheating of such furnaces is an operation quite as destructive to them as to the older types of apparatus.

Electrolytic processes are mostly continuous. They depend for their successful operation upon a certain ampere density at a fixed voltage, and from this it is obvious that the only method of control would be to cut out cells, or sets of cells, when the current supply must be reduced. Many of these operations are chemically reversible, and the effect of shutting down the process would involve considerable attendance.

Barring out as impracticable the filling in of all the depressions in the load diagrams, it will be seen that either process could be supplied with a capacity of 240 KW. for 20 hours per day in winter and for 24 hours in summer, without exceeding the winter maximum peak of 1643 KW. It is also apparent that a capacity of about 550 KW. could be supplied for 7 hours per night at any period of the year.

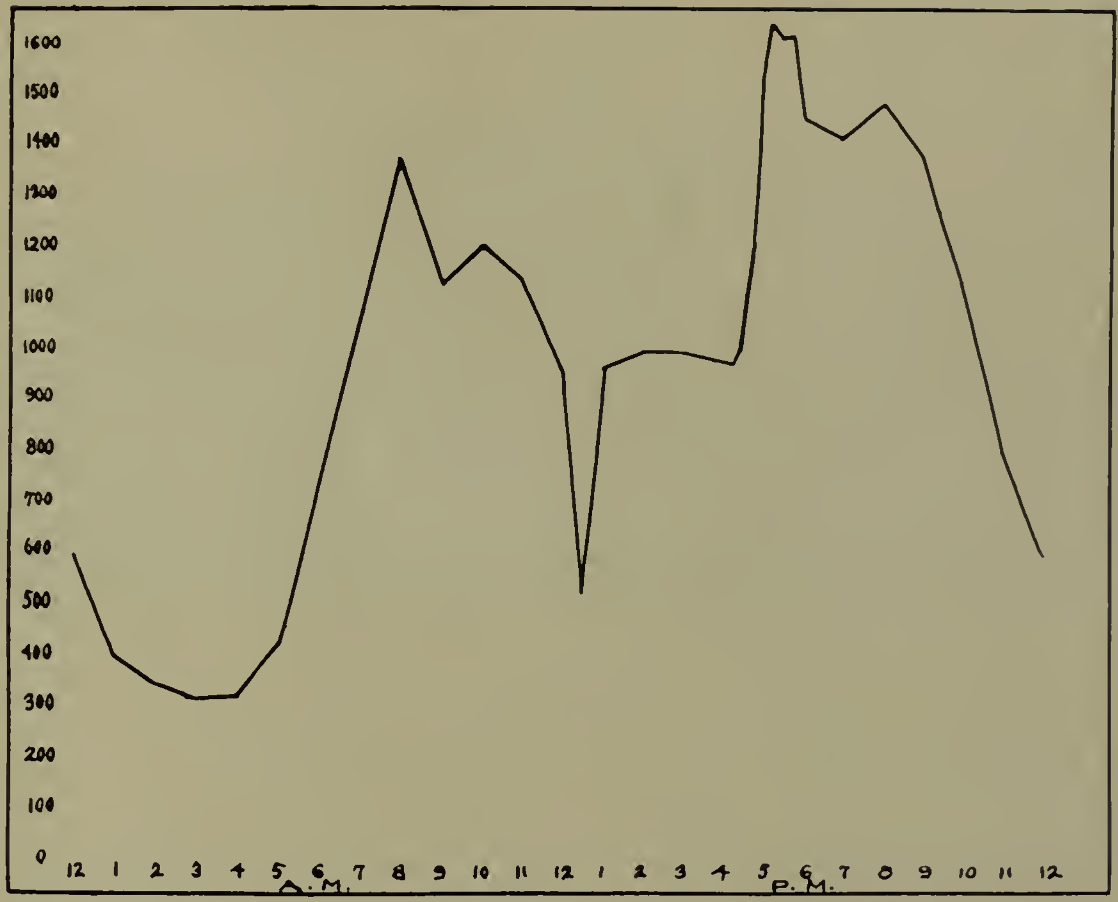


FIG. 4.—CURRENT GENERATED DECEMBER 15, 1905

The addition of these processes to the system would place on the first chart an area of 8650 KW.-hours and on the summer chart an area of 9610 KW.-hours.

The suggestion has been made of the use of storage batteries for the purpose of handling electrolytic work. As the current for such purposes must be sold at a low rate and the storage equipment is rather costly, this method of handling such a proposition would seem to merit little consideration.

While it may be possible to find processes to fit into the conditions shown in these diagrams, we have never seen anything of the nature of an efficient intermittent process. It may be concluded that electrothermic and electrolytic propositions must be considered on a straight 24-hour basis and handled in all respects as any other business of similar load factors.

It may also be concluded that for purposes of load equalization, it would only be possible to add such processes to any system as should be under the absolute control of the central station interests which were to supply them with electric current.

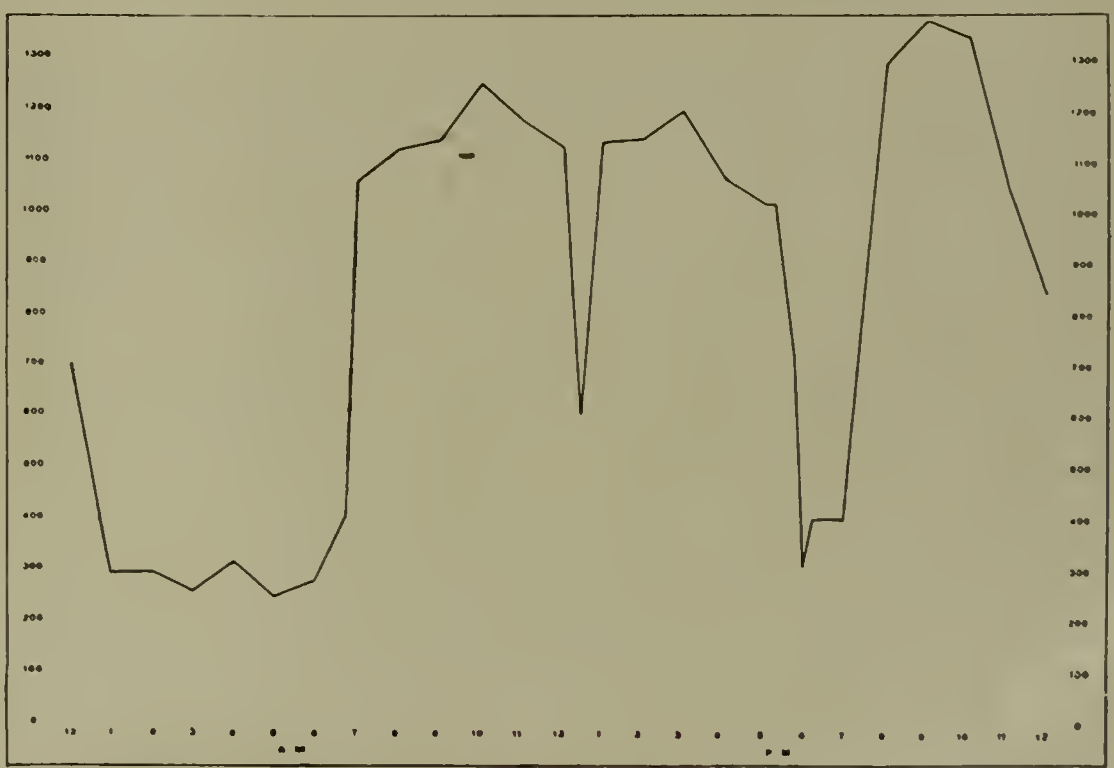


FIG. 5.—CURRENT GENERATED JUNE 13, 1906

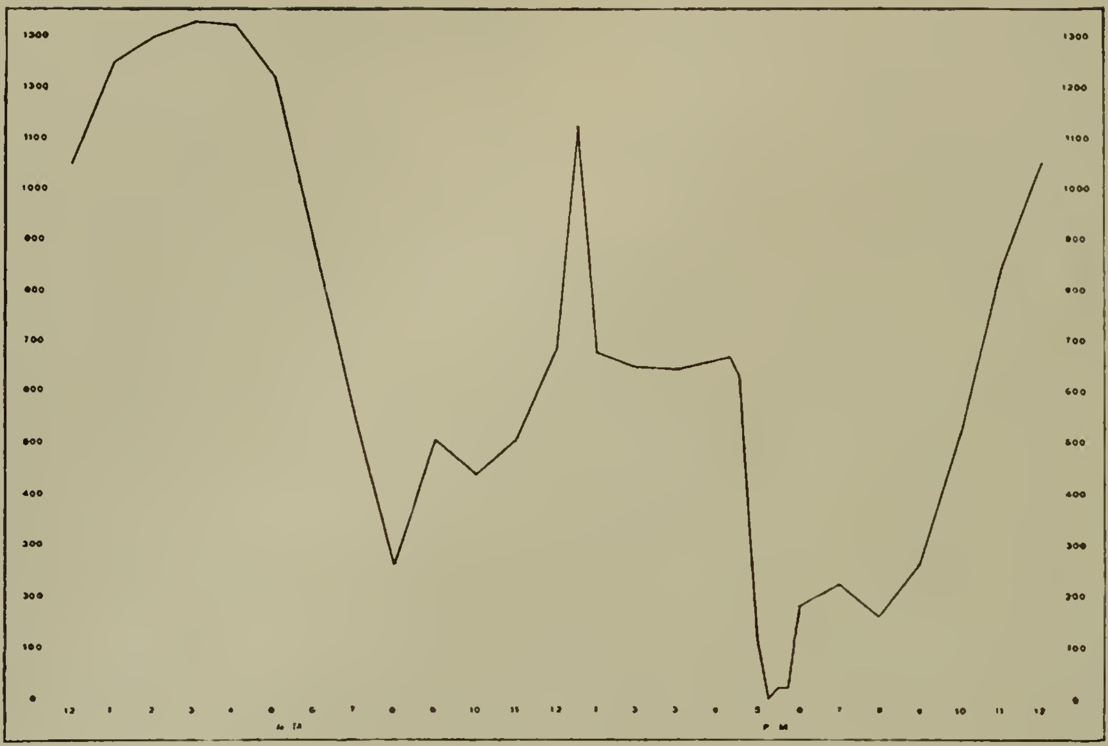


FIG. 6.—CURRENT AVAILABLE DECEMBER 15, 1905

One of the most important points in connection with such processes as involve the supply of large volumes of electrical energy is the question of location with regard to the station. The elimination of distribution expense to a large extent, as well as the fact that the service investment would be very low, should make quite a difference in the rates central stations would offer to such industries as located in their immediate vicinity.

While the tendency seems to be to locate such industries where water-power is available, there are other factors which may help the central station to secure consideration in the matter of current supply. The question of facility and low cost of transportation of raw materials and the location of principal market centres for finished product are important to any industry. While water-power may seem reasonable, these items of expense may make central station service in some other and more favoured locality the cheaper in the end.

There are some electrochemical industries located now in out-of-the-way places which could obtain better results near some of our great shipping centres, for the reason that the cost of transportation of raw and finished product plus the loss of certain by-products, which cannot now be utilized, more than offsets the advantages gained by the price of electricity at the present location. This condition of affairs was entirely unforeseen, and those interested had no one to show them the great white way leading to the central station.

A study of the various electrochemical industries will reveal that purchased electric power has been attractive to them for the reason that their inception was experimental and the exact type of equipment needed was unknown. The installation of large generating units under such circumstances was not warranted, whereas it was possible to purchase transforming apparatus adjustable to several possible conditions.

Here is where the advantage of our service comes in. We can meet these exact conditions, and, with the facilities it is possible to offer them and the low rates we can name them for 24-hour business, it would appear that the attraction of locating in accessible and desirable market centres should make it possible to present some very strong arguments for this class of business.

There is one point in considering these electrochemical and electrothermic propositions which should be represented in its true light in every possible case. In estimates of the current used for any given operation, either furnace or electrolytic, foreign usage, sanctioned by adoption on this side of the water, has adopted the unit, "electrical H. P.-year." In estimating, if a pound of finished product requires the expenditure of 746 watt-hours, for example, the cost of an electrical horse-power for one year is divided by 8760 (24 hours × 365 days), and the result is assumed as the cost of energy per pound of finished product.

The originator of this method was probably an optimist along the same lines as ourselves, in that he hoped to utilize every horse-power of generator capacity during 8760 hours per annum. Experience has taught us the true possibilities in this direction, but the truth does not seem to have penetrated deeply enough to make any change in the estimating methods of our sanguine electrochemists and electrometallurgists.

No process can continue at its maximum for 24 hours a day and 365 days per year. Furnaces need repairs, baths need renewing and overhauling; in fact, the very processes themselves require considerable current regulation and are not prosecuted at a maximum rate.

These, as well as humane reasons, prevent the fulfillment of the figure named. If the actual use averages from 50 to 70 per cent. of the maximum, and we have never seen the latter figures continually exceeded, quite a radical change in the estimated cost per pound of finished product, as well as per kilowatt-hour utilized, has been effected.

As a practical check upon this it is rather satisfactory to learn the electrical capacity of an installation,

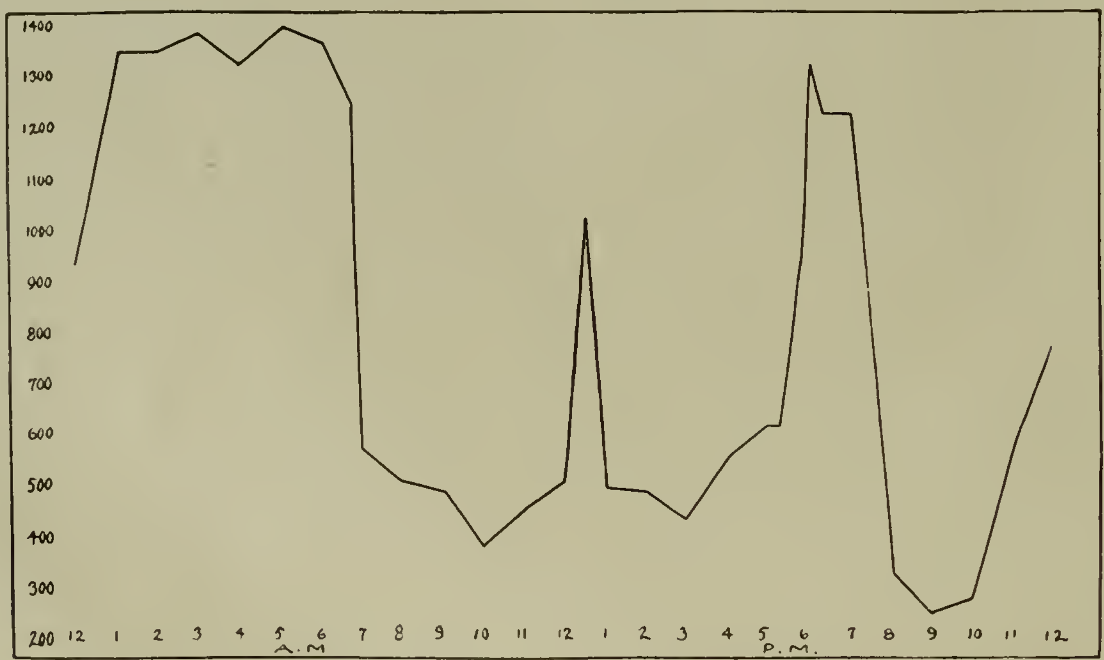


FIG. 7.—CURRENT AVAILABLE JUNE 13, 1906, AT THE MAXIMUM RATE OF DECEMBER 15, 1905

the amount of energy estimated per pound of product, and then to learn the actual amount of finished product turned out in a year. The results of this character of information received from several operations in different parts of the world would seem to indicate that, if the amount of calculated energy per pound is correct, the actual load factor of the plants runs from 30 to 50 per cent., based upon a 24-hour day and a calendar year.

The kilowatt-hour is the only true basis for calculation, and the cost of this unit for purposes of estimation should be based upon the cost of a kilowatt-year, modified by the actual or calculated load factor.

Computation along these lines, taking into account the cost of transportation of materials, will show the range of possible business in the field of large electric furnace and electrochemical operations.

As adjuncts to the power load, electrothermic appliances and electrochemical processes offer means of increasing the usefulness of the central station and broaden the field of salesmanship. The commercial departments which have for their motto "Electricity for everything everywhere," must view with some satisfaction the record of every new adaptation which brings them closer to their ideal.

The New Engineering Building of the University of Pennsylvania

THE NEW ENGINEERING BUILDING OF THE UNIVERSITY OF PENNSYLVANIA

On October 19, in the presence of representatives of six foreign governments, of the United States Army and Navy, and of scientific societies and educational institutions, was dedicated the new engineering building of the University of Pennsylvania, in Philadelphia.

The new building is the largest of the University group of seventy buildings, having a frontage of 300 feet and depth of 210 feet at one end, and 160 feet at the other. The approximate cost, including equipment, was nearly a million dollars. It is of fireproof construction, and the equipment is of the most modern and approved type. The exterior is of dark brick, with limestone thimmings, and the general architectural treatment is in the English Georgian style. There are three stories, with a basement covering about a third of the entire building, the total floor area being 128,000 square feet.

Electricity is used for lighting, current being supplied during times of small demand directly from the light and heat station, and when the demand is large, from the local plant in the centre of the basement. This plant consists of two 75-H. P. Westinghouse standard engines and one 25-H. P. engine direct connected to General Electric generators. Steam for the engines is supplied from the central station, and, after being used by the engines, is sent into the heating system of the building.

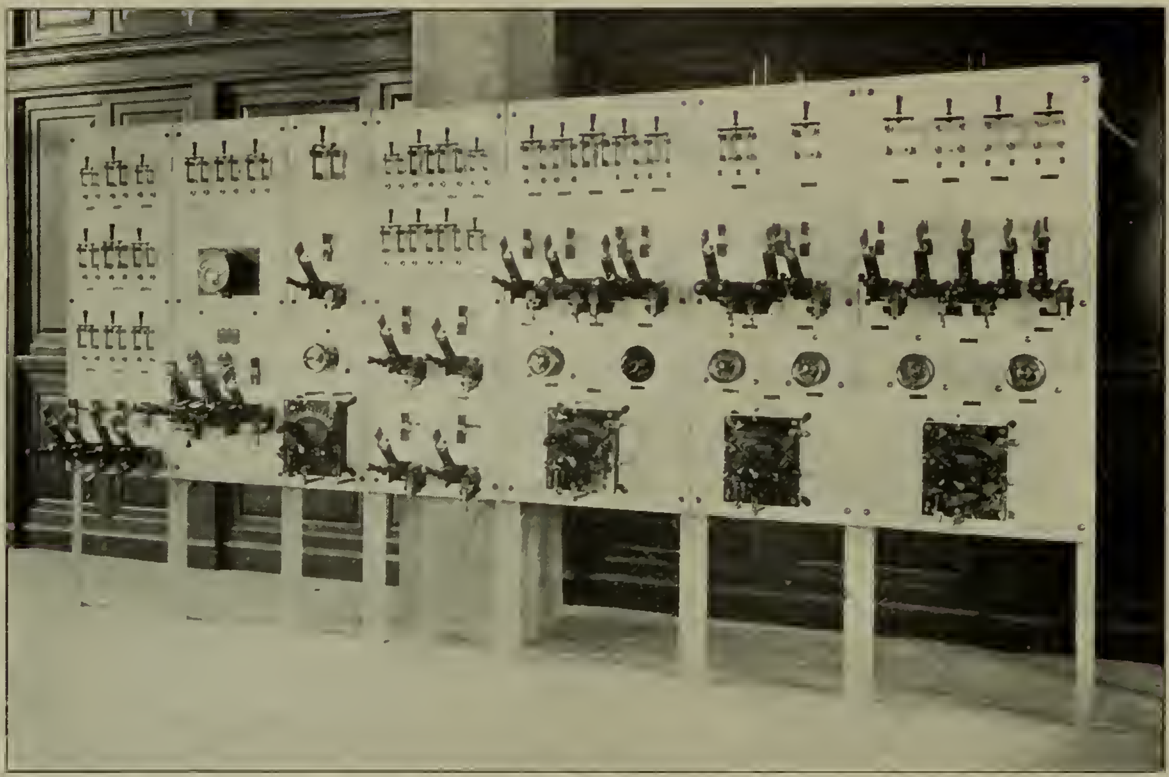
The lighting of the halls and library is by 50-candle-power meridian lamps. Class rooms are lit by clusters near the ceiling, while the drawing rooms and laboratories are lit generally by 5-ampere enclosed arc lamps with opaque bottom shade and concentric diffuser, placed about 15 feet apart. The uniformity of the light distribution is very fine.

In the building will be housed the departments of electrical, mechanical and civil engineering. It is with the first-named, however, that this article will concern itself.

Four electrical laboratories are provided, three on the first floor and one on the second. The beginners' laboratory, located on the first floor, is intended for measurement of current, resistance, inductance, capacity, etc., the calibration of voltmeters, ammeters, wattmeters, and the like. A floor space of 4500 square feet is divided into four separate testing rooms, and a concrete table and a galvanometer pedestal is provided for each student, accommodations for forty-two men being divided into four sections. Each of the four sections is provided with its own switchboard and its own storage battery insulation, enabling the entire number of men to be working at the same time.

The distributing switchboards have been designed for the work, and it is possible to get any combination of direct or alternating current for testing purposes. The apparatus supplied for these laboratories is, the University authorities believe, without its equal in any technical laboratory in this country.

THE DIRECT-CURRENT LABORATORY IN THE NEW ENGINEERING BUILDING OF THE UNIVERSITY OF PENNSYLVANIA



SWITCHBOARD IN THE ALTERNATING-CURRENT LABORATORY

THE SENIOR INSTRUMENT TESTING LABORATORY

The testing laboratory for direct current has a floor space of about 2000 square feet. It is on the ground floor, and has all its apparatus mounted on raised foundations, to which any dynamo or motor can be attached. Provision is made for handling twelve tests at one time, and the apparatus for each of these is complete. The distributing switchboard here supplies current of 110 volts, or at 6, 20, 110 or 150 volts, or any combination. The main power supply is taken from the building plant, 500 amperes being available at 110 volts.

All the dynamos used are motor driven, having field rheostats for regulating purposes. The appliances required for making these tests are supplied in such numbers that it is possible to run this entire laboratory at the same time, doing any of the work for which any of the machines may have been installed.

The alternating-current laboratory is located on the second floor, and covers a total floor space of over 2100 square feet. The wiring in this room is overhead from a switchboard. This board is over 14 feet in length, and all the circuits are protected by circuit-breakers. The apparatus installed is such that each testing place is practically a complete isolated plant.

For supplying current, four direct-connected generator sets are driven by direct-current motors, three sets having polyphase generators and the fourth having four single-phase, alternating-current generators.

To give some idea of the instrument equipment for each location, it may be said that there is the necessary equipment of prony brakes, scales, adjusting resistances, switches, thermometers, speed counters, stop-watches and tachometers, and, in addition, there are about ninety instruments, twenty of which are for direct current, the remainder being wattmeters, ammeters and voltmeters of suitable range for the rapid and accurate carrying on of the work, together with frequency indicators, power-factor indicators and synchronizers.

Two rooms are built especially for student's work in photometry, these having labyrinth entrances and dull black walls. A separate storage battery is provided for handling this work. Each photometer has a three-meter track and universal rotating stand. One is provided with the Lummer-Brodhum screen and one with the Bunsen screen, and a Flicker photometer is provided for use in measuring lights of dissimilar composition.

A standard room on the first floor, with a battery room directly beneath it in the basement, has been provided for doing fine electrical standardization work.

According to figures compiled by C. S. Norton, secretary of the Indiana Telephone Association, showing the growth of the independent telephone movement in the United States during the past eight years, a daily average of $100,000 capital was invested in such telephone property; 1200 subscribers were secured, three companies were incorporated, 200 miles of metallic toll lines were constructed, and 120 new stockholders were secured as a daily average.

Throughout the Scottish coal fields, says "The Electrical Review," of London, it is evident that for the next two years a large amount of electrical machinery will have to be installed, both for use for plants which are at present going in, and for developing the new pits which are being sunk. Many mine managers also in the older parts of the coalfields are now face to face with the alternatives of having to close their colleries owing to the richest seams having been worked out, or installing mechanical cutters and other up-to-date appliances in order to work the thinner seams at a profit.

Some Characteristics of Coal as Affecting Performance with Steam Boilers

By W. L. ABBOTT, of the Chicago Edison Company

A Paper Read at a Recent Meeting of the Western Society of Engineers

THE capacity and efficiency obtained with a steam boiler is the result of many influences more or less variable in character, and for the purpose of studying some of these influences, certain experiments were conducted in which coal screenings were used, the results of which are presented in this paper.

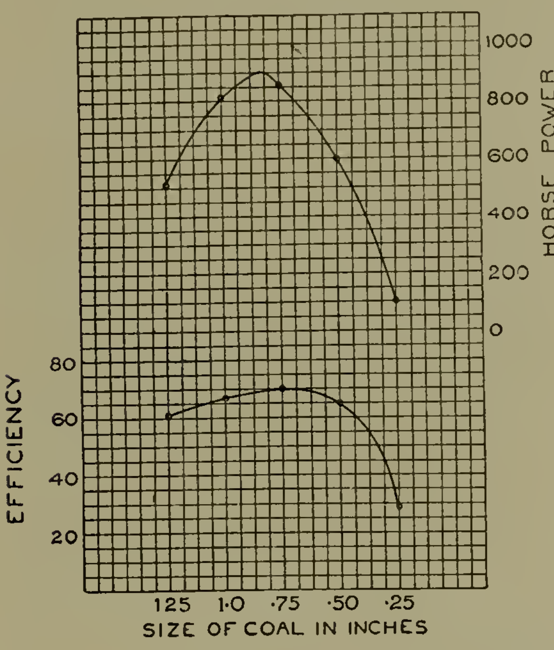


FIG. 1.—EFFECT ON CAPACITY AND EFFICIENCY DUE TO COAL OF DIFFERENT SIZES

The apparatus employed in the researches to be considered consisted of two Babcock & Wilcox boilers, one with a tube surface 14 tubes high and 18 wide, and having approximately 5000 square feet of heating surface. It was fitted with a chain grate stoker, 75 square feet in area, which discharged the gases of the fire from under an ignition arch, 5 feet long, immediately among the tubes of the boiler. The boiler was also fitted with a Babcock & Wilcox superheater having an approximate area of surface of 1000 square feet. The other apparatus employed in one of the series of tests differed only in size of its boiler, which was 12 tubes high and 16 wide, with 4000 square feet of heating surface. It was provided with a superheater and had a chain grate stoker 66 square feet in area.

The experiments were for the purpose of studying the effect on capacity and efficiency due to coal of different sizes, the influence of ash in coal on capacity and efficiency, the effect of variation in size of coal screening, and the results of different thicknesses of fire.

The experiments illustrated by Fig. 1 consisted in the use of coal separated into various sizes by means of screens having the following square openings: 0.25, 0.50, 0.75, 1.0 and 1.25 inch. The coal was all from one lot, so that the different portions resulting from the screening process were necessarily the "same kind of coal," except that some portions were uniformly larger and others smaller, and that the smallest, on account of its size, was higher in ash.

As shown by the curves of efficiency and capacity in the diagram, five tests were made, each with a different size of coal. In all other respects, however, everything was equal; thus the influencing conditions, except that due to size of coal, were constant. In this way, relative values for the feature studied were obtained as shown by the diagram.

The percentage of ash in the dry coal of the various sizes were as follows:—

	Square Screens, Through	Over	Ash in Dry Coal
Size of coal, inch.....	1.25	1.00	13.7
Size of coal, inch.....	1.00	0.75	14.0
Size of coal, inch.....	0.75	0.50	15.6
Size of coal, inch.....	0.50	0.25	20.8
Size of coal, inch.....	0.25	0.00	30.8

The high per cent. in the smallest size is not due to ash in the coal itself, but to the fact that all of the fine sized foreign matter separated from larger coal, or which comes from roof or floor of the mine, naturally finds its way into this smaller coal.

INFLUENCE OF ASH IN COAL ON CAPACITY AND EFFICIENCY

Fig. 2 gives results of eighteen tests made to determine the effect of varying quantities of ash associated with coal. One result of its presence is to reduce the heating power, owing to displacement of combustible matter. Therefore, in connection with this, ash may be considered as a dilutant, and if this were the only result of its presence it would have no effect on heat effi-

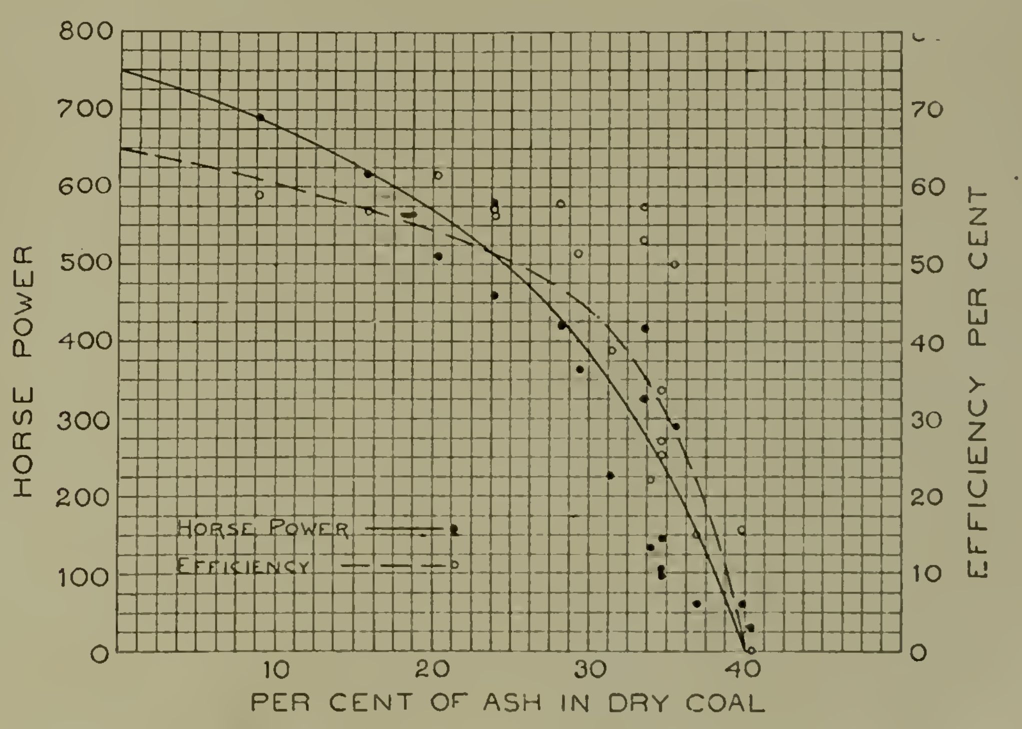


FIG. 2.—INFLUENCE OF ASH IN COAL ON CAPACITY AND EFFICIENCY

ciency secured through a boiler. A proportionately less amount of water would be evaporated by a pound of such mixture of ash and coal, of course, but efficiency would not be affected. If, however, ash acts in some other way as well, such as an obstruction to the combustion process, the effect of its presence is doubly harmful.

To insure that the result would not be affected by any influence other than that of the ash, special coal was used which came from the No. 7 seam, north of Marion in Williamson County, Ill. It was prepared in a Stewart washer, and is known to the trade as No. 4 washed coal, a size made by passing over a screen having $\frac{1}{4}$-inch round openings, and through one having similar $\frac{1}{2}$-inch openings. Its composition is represented in Table I.

TABLE I.
Composition of Coal

Moist coal:	
Moisture	7.48
Ash	8.23
B. T. U.	12,191
Dry coal:	
Ash	8.90
B. T. U.	13,176
Pure coal:	
B. T. U.	14,463

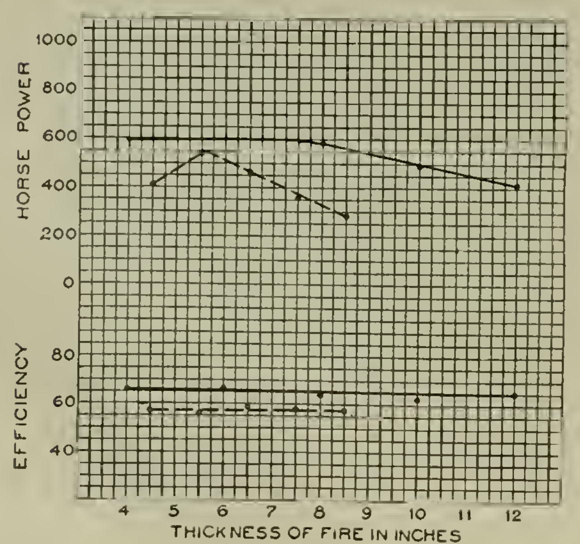


FIG. 5.—RESULT OF DIFFERENT THICKNESSES OF FIRE

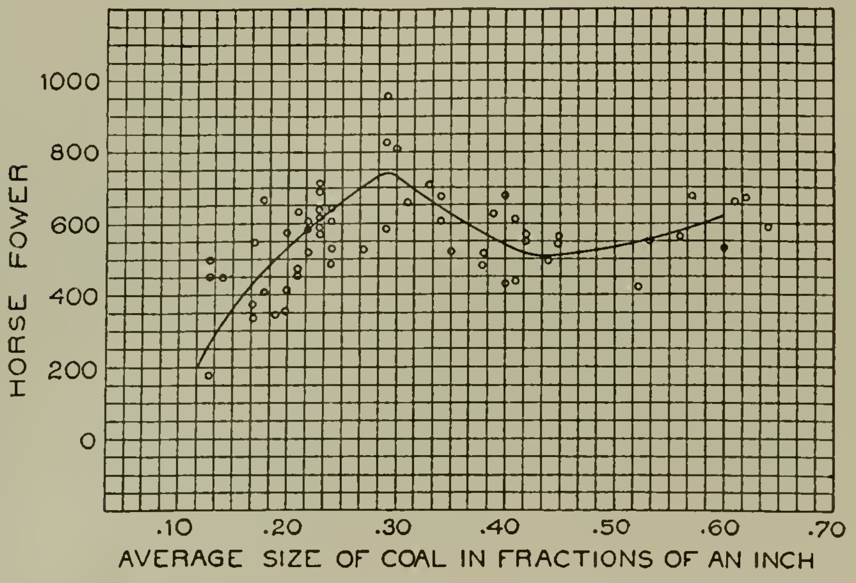


FIG. 3.—EFFECT ON OUTPUT OF VARIATION IN SIZE OF COAL SCREENINGS

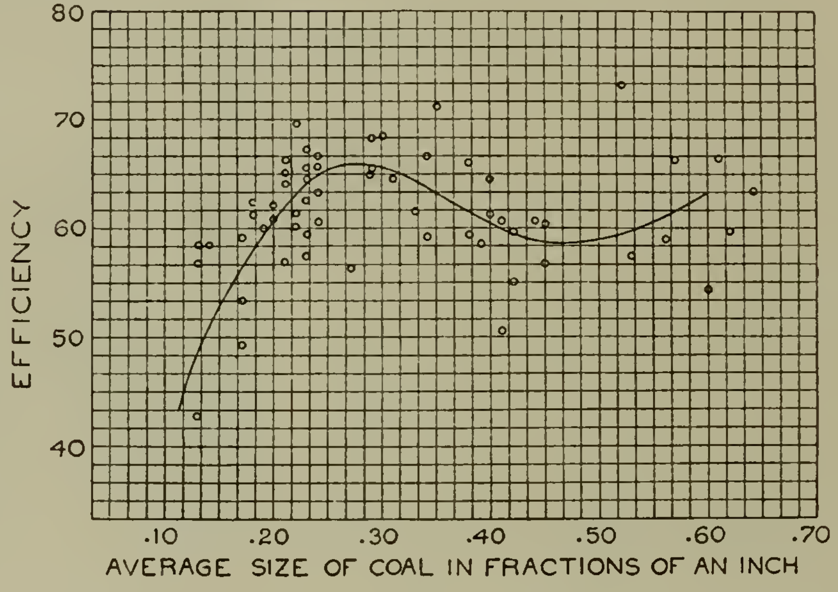


FIG. 4.—EFFECT ON EFFICIENCY OF COAL OF DIFFERENT SIZES

The test indicated by the two points in Fig. 2 showing highest efficiency and capacity was made with coal just as it arrived, or, in other words, was of the composition shown by the analysis. Beginning with the test of the second day, a quantity of refuse from the stoker ash pits was added to the coal to be used. This refuse was first weighed and the large pieces broken up, after which it was thoroughly mixed with the coal in the required proportion and increasing amounts were added in each test which followed. This fuel composition was, of course, weighed as used and a sample of it selected for analysis in the regular manner.

It appears from the diagram that useful effect from the fuel drops to zero with 40 per cent. of ash, notwithstanding the fact that the other 60 per cent. of the composition was pure coal. The fact should be emphasized, that although over half of the composition fed to the fire was fuel, it burned without producing any useful effect, for which there are two reasons: one, that on account of obstructed air supply through the fuel bed, incomplete combustion and escaping hydrocarbons carried away a portion of the heat, because the gases passed immediately among the tubes of the boiler. The other is, that owing to the presence of an excess of ash, the percentage of fuel on the rear portion of the grate is greatly reduced. On this account a larger proportion of the air passing through the fuel bed does not combine with the fuel, but enters the furnace as free air. As the prime function of a furnace is to heat the gases passing through it, any increase in the amount of air entering the furnace without a corresponding increase in the amount of fuel burned must lower the furnace temperature.

This lowering of temperature, besides making a long, smoky flame, which reaches up among the boiler tubes and is there chilled to below the burning point, also reacts on the fuel bed, reducing the rate of combustion and still further increasing the adulteration of the furnace gases with free air. When the temperature of the furnace has been thus reduced to about 600 degrees Fahr. the boiler is unable to absorb any more heat than is necessary to make up for radiation losses.

It will be observed that the points on the diagram do not fall in symmetrical order. This is particularly true of ash percentages of about 34, which may be explained by the refuse used in these tests being probably of a more fusible character than with others. These tests with the ash composition were made with the smaller boiler above mentioned.

EFFECT OF VARIATION IN SIZE OF COAL SCREENINGS

In Illinois and Indiana coal not sold as mine run is separated largely as lump and screenings, and such screenings furnish about 90 per cent. of the stoker fuel used in Illinois.

Figs. 3 and 4 illustrated the result of sixty-two tests. With each, the size of coal is measured by screens with square openings, ranging in dimensions from $\frac{1}{4}$ to $1\frac{1}{2}$ inches, advancing by $\frac{1}{4}$ inch, and the average sizes of coal, as shown at the base of the diagrams, were calculated from sizing tests made with these screens, and represent the dimensions in fractions of an inch of openings in a screen which would allow one-half of the coal to pass through and the other half to go over the screen. It is this that is designated as its average size.

Fig. 3 shows the effect produced on horse-power output owing to this variation in size of the coal, and Fig. 4 illustrates the resulting efficiency from the same cause and for the same tests.

The curves for both efficiency and capacity drop midway between the tests with both small and large coal. This is a peculiarity which may be explained as follows:—Performance becomes better as the size of coal increases, until a point is reached when the quantity of large pieces becomes so great that there is not enough fine material to properly close the interstices between. The result is that the performance drops off, due to excess of air, until a condition is reached when all the pieces of fuel approach uniformity, when, owing to greater agreement in size, they fit together better, and, in a measure, produce a homogeneous mass similar to that secured by the fine dust filling the spaces in the fuel bed in the first place.

The presence of fine dust in excess is a great and important source of trouble. Referring to Fig. 1, coal through a ¼-inch square screen produced only 108 H. P., yet a size of fuel, known in Illinois as No. 5 washed coal, which will pass through a ¼-inch round hole (a smaller aperture than the square opening), will produce as high as 600 H. P. under the same boiler.

It is true that the lower ash content of the washed coal has a considerable influence, but this is offset by the larger size of the square screen as against the round one. To arrive at a better understanding of the physical make-up of these two characters of fuel, tests were made of the dust of each, using that quantity which would pass through a 20-mesh screen, with the results shown in Table II.

The quantity of the extremely fine dust through the 100-mesh screen is shown to be almost three times as much in the unwashed as with the washed coal. The third line of the table is an average from five tests taken from different lots of screenings, and shows an approximate agreement with the quantities from the dust through the ¼-inch square screen, from which it follows that the presence of the fine dust has an enormous influence on the burning of the fuel.

RESULT OF DIFFERENT THICKNESSES OF FIRE

An excess of air accompanies a thin fire, and because of it efficiency produced through the boiler is affected. On the other hand, a thick fire reduces the excess of air, but increases the volume of hydrocarbon gases which leave the surface, or, in other words, it makes more smoke.

If a furnace is located between the boiler and stoker, these gases will be burned; otherwise they will largely

The curves of efficiency in this diagram illustrate a constant heat efficiency produced through the boiler for a full working range in thickness of fire, insuring not only maximum

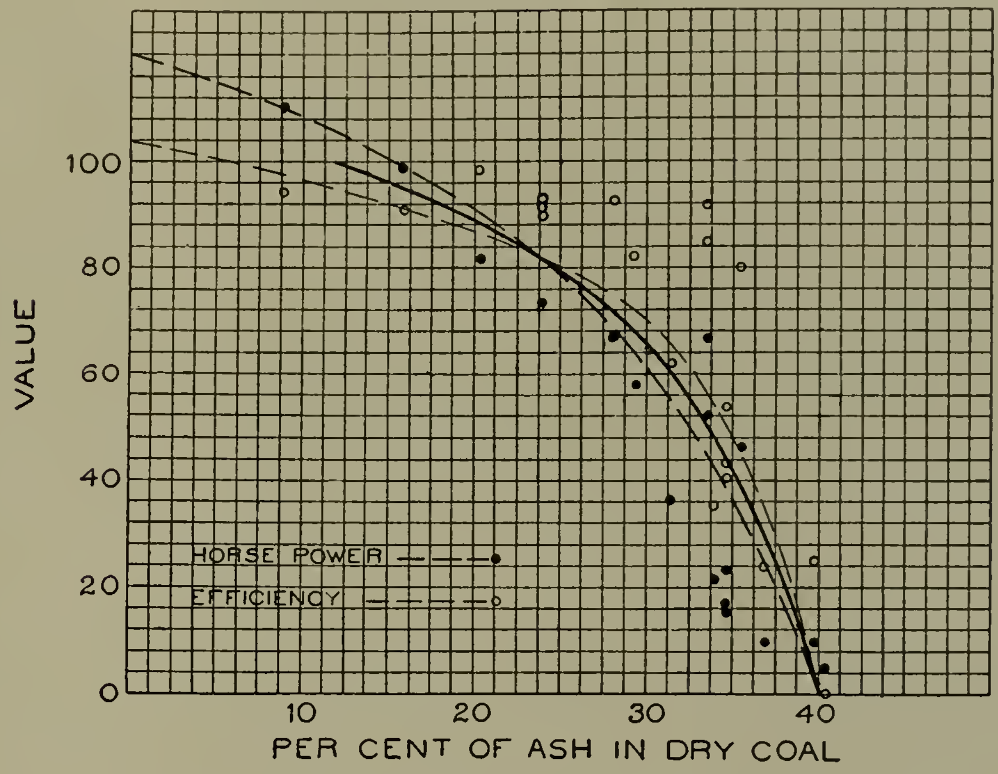


FIG. 6.—EFFECT OF PERCENTAGE OF ASH IN DRY COAL

escape among the tubes of the boiler, as they did in this case. Therefore, under these conditions a thin fire increases the loss due to excess of air, but decreases that due to smoke and incomplete combustion.

On the other hand, a thick fire reduces the excess of air, but increases the smoke and escaping combustible gas, and so the best thickness of fire may be a matter of importance. With this type of boiler of a height of nine tubes when served with chain grate stokers discharging immediately among the tubes, it is always most economical to produce as large a volume of smoke as possible with the coal being used. With boilers of fourteen tubes in height, the conditions are different, because such boilers are more efficient.

With an ideal boiler the final temperature would be the same as the atmosphere; therefore, an unlimited excess of air could be used without causing heat loss. No practical boiler can, of course, be an ideal one, but the Babcock & Wilcox type of fourteen tubes high approaches much nearer to it than does one of nine high, and for that reason is more efficient, and in connection with this is quite unique, as Fig. 5 will show.

excess of air, but incomplete combustion loss as well, yet efficiency remained uniform, and the only opportunity for the "skillful" and "intelligent" fireman is in selecting that thickness best suited to capacity requirements.

The coal used in these two series of tests was very uniform in size and ash content, and for these reasons was well suited to the purpose of the experiments. In the series with thickness of fire from 4½ to 8½

TABLE II.

Quantity and Size of Coal Dust Below 20-Mesh Screen. Percentage of Different Sizes

Dust Sample	Through 20 and Over 40	Through 40 and Over 60	Through 60 and Over 80	Through 80 and Over 100	Through 100
No. 5 washed	63.36	16.78	6.51	2.93	10.42
Dust through ¼-inch square screen.	46.10	13.87	8.18	3.84	28.01
Average of five tests from ordinary screenings	48.50	13.78	7.57	4.38	25.74

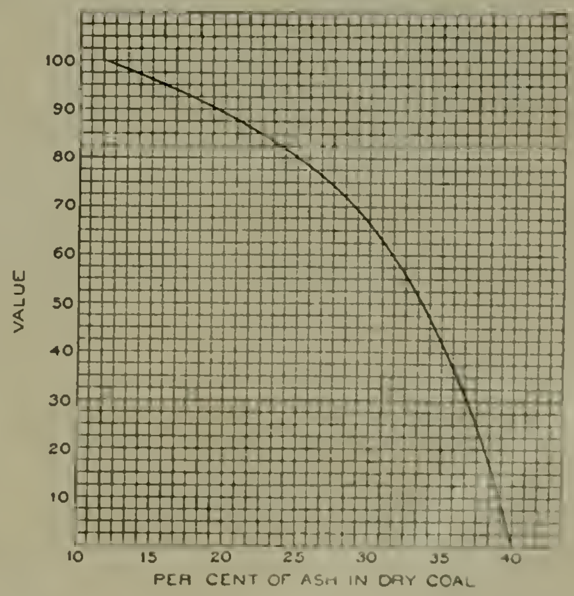


FIG. 7.—VALUE OF FUEL WITH REFERENCE TO PERCENTAGE OF ASH

inches, what is known as No. 5 washed coal was used, a size which passes through a screen having round openings $\frac{1}{4}$ inch in diameter.

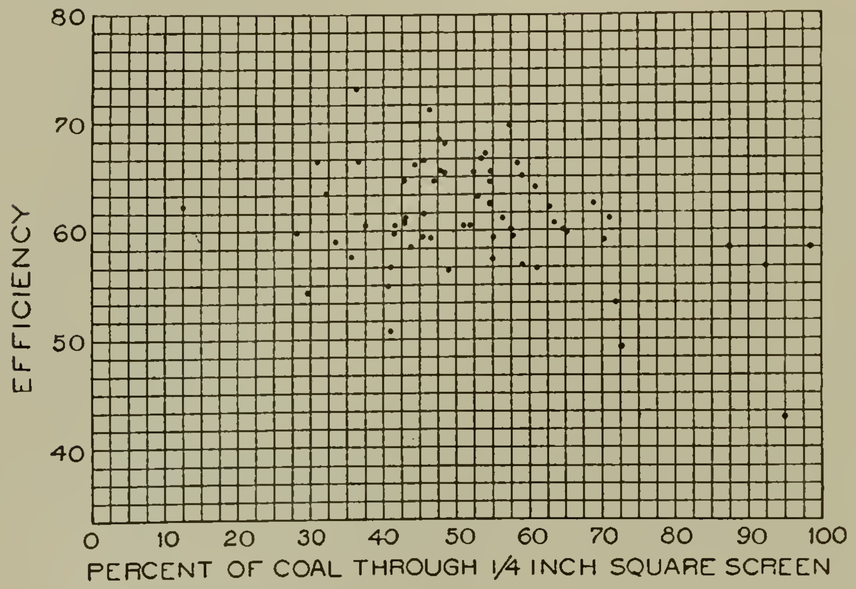


FIG. 8.—EFFECT OF SCREENED COAL ON EFFICIENCY

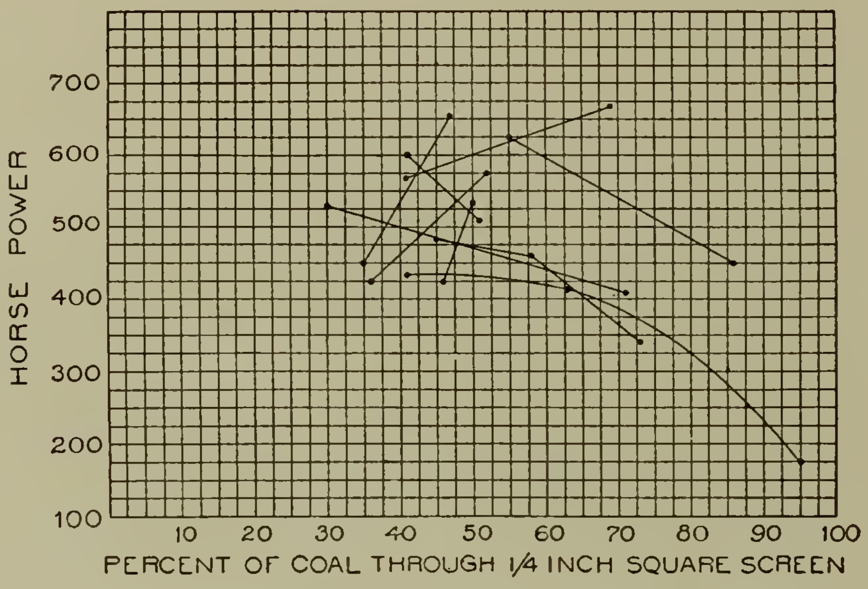


FIG. 9.—EFFECT OF SCREENED COAL ON HORSE-POWER

With the other series and a larger range in thickness, washed screenings were employed.

Table III. gives values in one figure for screenings containing different percentages of ash, and of variation in size, as measured by that portion passing through a $\frac{1}{4}$-inch round screen. The following detailed statement explains how this table was prepared:—

The value of coal screenings is affected by four variables, which are heating power, moisture, ash and size of the pieces of coal. Heating power in Illinois and Indiana of the pure coal,—in other words, free from ash and moisture, the real coal,—ranges from 13,800 as the minimum to a maximum of 14,500 B. T. U. per pound, and moisture from about 9 to 14 per cent. These two characteristics, however, are of minimum importance, as either can affect the result by only a comparatively small amount.

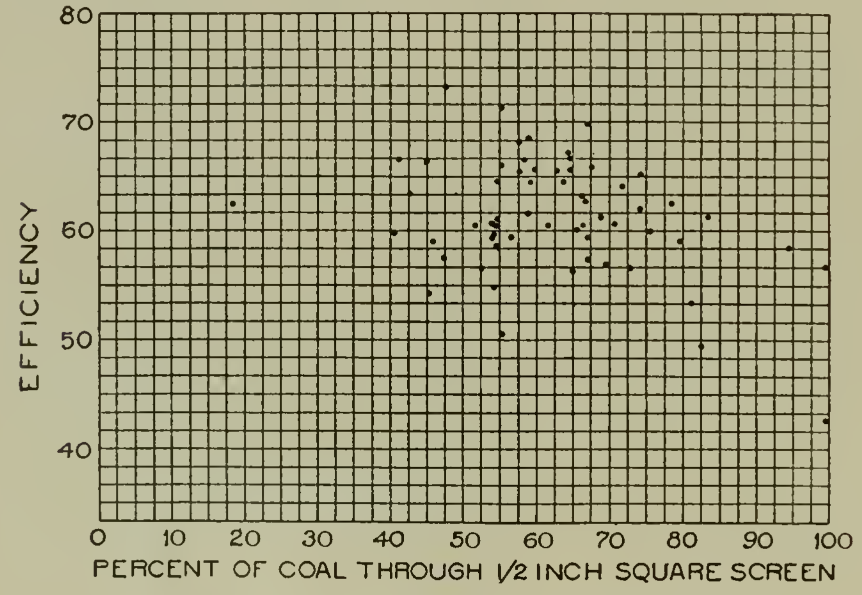


FIG. 10.—EFFECT OF SCREENED COAL ON EFFICIENCY

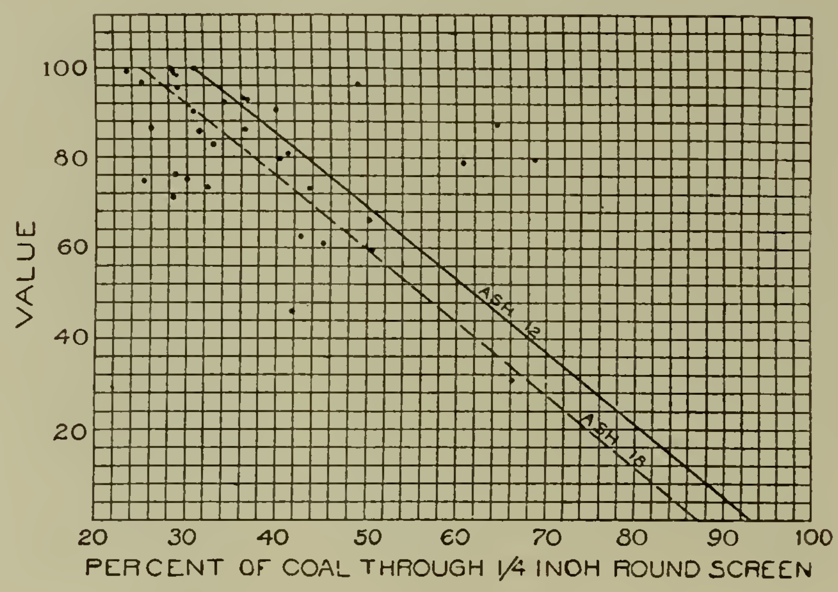


FIG. 11.—EFFECT OF SCREENED COAL ON VALUE

Of the other two features, namely, amount of ash and size of the pieces, each may exert an influence of such moment that they cause the fuel to be valueless. Thus, in fuel inspection service, it may be necessary to test only the latter characteristics; therefore, Table III. is based on variation in percentage of ash and on size of the coal, moisture and heating power being assumed as constant.

The fuel in service under a boiler produces two results, one of efficiency and the other of capacity, and capacity, or, in other words, quantity of steam produced, is a matter of great importance. Therefore, if these two effects may be averaged and treated as a single value, the problem is much simplified.

Inspection of Figs 3 and 4 shows that resulting capacity and efficiency are approximately the same, and that the condition of fuel which results in a high efficiency also produces large capacity. This makes it possible to assign two values to the fuel, one applying to ash content, the other to its size, each of these values embracing efficiency and capacity as a unit.

In placing the effect due to ash in shape for use in preparation of Table III., Fig. 6, which is a reproduction of Fig. 2, has a heavy curve, drawn midway between those of efficiency and capacity. This average curve represents the value of the fuel as far as ash is concerned, which appears to be 100 per cent., with 12 per cent. of ash in the dry screenings, and, according to this value, could be greater than 100 per cent. But 12 per cent. represents an average minimum ash content for coal screenings in Illinois and Indiana at the present time; therefore, such fuel is the best obtainable, and for this reason may have a value of 100 per cent. assigned to it.

Thus Fig. 7 contains a curve showing value taken from Fig. 6, and without the complication of curves and points in the latter, and ash values were taken directly from it for use in the compilation of Table III.

The feature of size is a more diffi-

PERCENT OF ASH IN DRY COAL

Percentage of Coal through 1/4-inch Round Screen	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
31	100	99	98	96	95	94	92	91	89	88	86	84	82	80	78	76	73	70	67	63	58	53	48	42	35	28	20	10	0
32	98	97	96	94	93	92	90	89	87	86	84	82	80	78	76	74	71	68	65	61	56	51	46	40	33	26	18	8	
33	96	95	94	92	91	90	88	87	85	84	82	80	78	76	74	72	69	66	63	59	54	49	44	38	31	24	16	6	
34	94	93	92	90	89	88	86	85	83	82	80	78	76	74	72	70	67	64	61	57	52	47	42	36	29	22	14	4	
35	93	92	91	89	88	87	85	84	82	81	79	77	75	73	71	69	66	63	60	56	51	46	41	35	28	21	13	3	
36	91	90	89	87	86	85	83	82	80	79	77	75	73	71	69	67	64	61	58	54	49	44	39	33	26	19	11	1	
37	90	89	88	86	85	84	82	81	79	78	76	74	72	70	68	66	63	60	57	53	48	43	38	32	25	18	10		
38	88	87	86	84	83	82	80	79	77	76	74	72	70	68	66	64	61	58	55	51	46	41	36	30	23	16	8		
39	87	86	85	83	82	81	79	78	76	75	73	71	69	67	65	63	60	57	54	50	45	40	35	29	22	15	7		
40	85	84	83	81	80	79	77	76	74	73	71	69	67	65	63	61	58	55	52	48	43	38	33	27	20	13	5		
41	83	82	81	79	78	77	75	74	72	71	69	67	65	63	61	59	56	53	50	46	41	36	31	25	18	11	3		
42	82	81	80	78	77	76	74	73	71	70	68	66	64	62	60	58	55	52	49	45	40	35	30	24	17	10	2		
43	80	79	78	76	75	74	72	71	69	68	66	64	62	60	58	56	53	50	47	43	38	33	28	22	15	8			
44	78	77	76	74	73	72	70	69	67	66	64	62	60	58	56	54	51	48	45	41	36	31	26	20	13	6			
45	77	76	75	73	72	71	69	68	66	65	63	61	59	57	55	53	50	47	44	40	35	30	25	19	12	5			
46	75	74	73	71	70	69	67	66	64	63	61	59	57	55	53	51	48	45	42	38	33	28	23	17	10	3			
47	74	73	72	70	69	68	66	65	63	62	60	58	56	54	52	50	47	44	41	37	32	27	22	16	9	2			
48	72	71	70	68	67	66	64	63	61	60	58	56	54	52	50	48	45	42	39	35	30	25	20	14	7				
49	71	70	69	67	66	65	63	62	60	59	57	55	53	51	49	47	44	41	38	34	29	24	19	13	6				
50	69	68	67	65	64	63	61	60	58	57	55	53	51	49	47	45	42	39	36	32	27	22	17	11	4				
51	67	66	65	63	62	61	59	58	56	55	53	51	49	47	45	43	40	37	34	30	25	20	15	9	2				
52	66	65	64	62	61	60	58	57	55	54	52	50	48	46	44	42	39	36	33	29	24	19	14	8	1				
53	64	63	62	60	59	58	56	55	53	52	50	48	46	44	42	40	37	34	31	27	22	17	12	6					
54	62	61	60	58	57	56	54	53	51	50	48	46	44	42	40	38	35	32	29	25	20	15	10	4					
55	61	60	59	57	56	55	53	52	50	49	47	45	43	41	39	37	34	31	28	24	19	14	9	3					
56	59	58	57	55	54	53	51	50	48	47	45	43	41	39	37	35	32	29	26	22	17	12	7	1					
57	58	57	56	54	53	52	50	49	47	46	44	42	40	38	36	34	31	28	25	21	16	11	6						
58	56	55	54	52	51	50	48	47	45	44	42	40	38	36	34	32	29	26	23	19	14	9	4						
59	54	53	52	50	49	48	46	45	43	42	40	38	36	34	32	30	27	24	21	17	12	7	2						
60	53	52	51	49	48	47	45	44	42	41	39	37	35	33	31	29	26	23	20	16	11	6	1						
61	51	50	49	47	46	45	43	42	40	39	37	35	33	31	29	27	24	21	18	14	9	4							
62	49	48	47	45	44	43	41	40	38	37	35	33	31	29	27	25	22	19	16	12	7	2							
63	48	47	46	44	43	42	40	39	37	36	34	32	30	28	26	24	21	18	15	11	6	1							
64	46	45	44	42	41	40	38	37	35	34	32	30	28	26	24	22	19	16	13	9	4								
65	45	44	43	41	40	39	37	36	34	33	31	29	27	25	23	21	18	15	12	8	3								
66	43	42	41	39	38	37	35	34	32	31	29	27	25	23	21	19	16	13	10	6	1								
67	41	40	39	37	36	35	33	32	30	29	27	25	23	21	19	17	14	11	8	4									
68	40	39	38	36	35	34	32	31	29	28	26	24	22	20	18	16	13	10	7	3									
69	38	37	36	34	33	32	30	29	27	26	24	22	20	18	16	14	11	8	5	1									
70	37	36	35	33	32	31	29	28	26	25	23	21	19	17	15	13	10	7	4										
71	35	34	33	31	30	29	27	26	24	23	21	19	17	15	13	11	8	5	2										
72	33	32	31	29	28	27	25	24	22	21	19	17	15	13	11	9	6	3											
73	32	31	30	28	27	26	24	23	21	20	18	16	14	12	10	8	5	2											
74	30	29	28	26	25	24	22	21	19	18	16	14	12	10	8	6	3												
75	28	27	26	24	23	22	20	19	17	16	14	12	10	8	6	4	1												
76	27	26	25	23	22	21	19	18	16	15	13	11	9	7	5	3													
77	25	24	23	21	20	19	17	16	14	13	11	9	7	5	3	1													
78	24	23	22	20	19	18	16	15	13	12	10	8	6	4	2														
79	22	21	20	18	17	16	14	13	11	10	8	6	4	2															
80	20	19	18	16	15	14	12	11	9	8	6	4	2																
81	19	18	17	15	14	13	11	10	8	7	5	3	1																
82	17	16	15	13	12	11	9	8	6	5	3	1																	
83	16	15	14	12	11	10	8	7	5	4	2																		
84	14	13	12	10	9	8	6	5	3	2																			
85	12	11	10	8	7	6	4	3	1																				
86	11	10	9	7	6	5	3	2																					
87	9	8	7	5	4	3	1																						
88	7	6	5	3	2	1																							
89	6	5	4	2	1																								
90	4	3	2																										
91	3	2	1																										
92	1																												
93	0																												

TABLE III.—COAL VALUES FOR SCREENINGS CONTAINING DIFFERENT PERCENTAGES OF ASH

cult problem than that of ash, as the following will show:—After the tests represented in Figs. 3 and 4 (sixty-two in number) were finished, Fig. 8 was plotted, using percentages of coal through a ¼-inch square screen. The diagram for efficiency only is shown, because that for capacity gave no different result. It is apparent that the arangement of points fails to show any harmful effect due to presence of excessive quantity of fine dust.

The fuel used in these sixty-two tests was ordinary screenings, containing varying amounts of ash. To ascertain if this variable ash content could be the cause of the failure of Fig. 8 to show harmful effect of fine dust, individual tests were used in the plotting of Fig. 9, the ash content for the tests shown by any one of the curves being constant, while the size, as represented by the percentage through the ¼-inch square screen, varied.

The result of this analysis made it appear that the presence of finer sizes was sometimes harmful, and in other cases beneficial. The scheme of average size was then adopted and employed, with the result shown by Figs. 3 and 4, described in the first division of this paper, and as a check on the conclusions of these two diagrams, Fig. 10 was plotted, based on percentages through a ½-inch screen.

With ½-inch screenings, this size is nearer to the general average than that of ¼ inch, and it is apparent that a curve may be drawn through the points which will show a falling off in efficiency or capacity, with increase in quantity of fuel through the ½-inch. screen, which helps to corroborate the conclusions of Figs. 3 and 4.

In coal inspection service, it is quite essential that the tests be simple and few in number, but determination of the average size requires that several screens be employed, involving a large amount of work, as well as difficult calculation, and for this reason there is a great advantage in using but one screen. The ¼-inch size having received more or less favourable consideration, in working out a scheme for its use in connection with Table III., all of the tests which showed a capacity below 575 H. P. were taken. With these data Fig. 11 was prepared.

The average ash in the dry coal for these tests was 18 per cent. A curve representing values for this ash content, and also for standard ash of 12 per cent., being drawn, the latter curve gave values for use in Table III. The quantities of coal were transposed from that through the ¼-inch square to a ¼-inch round screen. Thus the final result for ash shown by Fig. 7 and that for size by Fig. 11, furnished data used for calculating the final combined values in Table III., from which it appears that screenings, having 12 per cent. of ash or less, and of a size that no more than 31 per cent. will pass a ¼-inch round screen, may be considered of 100 per cent. value, or, in other words, sufficiently good for the purpose.

Basing conclusions on the measurement given by any one screen as arbitrary, as four points in Fig. 11 indicate, therefore, while Table III. may be depended on to identify all of the coal containing an excess amount of fine sizes, it will, in a few cases, condemn satisfactory fuel.

This paper does not presume to lay down the ultimate laws by which fine coals may be graded in value, but rather to point out the fact that such laws, although at present obscure, do exist, and that our conclusions drawn from numerous tests are as herein indicated.

During the year 1905 there was produced in Illinois and Indiana about 50,000,000 tons of coal, 48 per cent. of which was $1\frac{1}{4}$-inch screenings, and although it was not in every case separated from the lump, we can truthfully say that this 48 per cent., or 20,000,000 tons of screenings, was sold at the mine at an average price not to exceed two-thirds of its cost of production, and this same fine coal was used for making steam at an average efficiency of less than 50 per cent. These two facts are sufficient to warrant further investigation of this little-known subject.

Course of Lectures on Electricity at the Brooklyn Institute of Arts and Sciences

An unusually interesting series of lectures on electricity have been arranged by the Department of Electricity of the Brooklyn Institute of Arts and Sciences. Dr. Samuel Sheldon, president of the American Institute of Electrical Engineers, is president of the department. Frederick V. Henshaw is secretary.

The first lecture of the series was given on October 11, by William Lord Bliss, on "The Electric Illumination of Trains." The other lectures in the course follow:—

November 8.—"Extra Long-Distance Transmission of Power by Continuous Currents," by Ralph D. Mershon, of New York.

December 13.—"The Place of the Steam Turbine in an Electric Light Plant," by Walter F. Wells, manager of the Edison Electric Illuminating Company, of Brooklyn.

January 10.—"The Mercury-Arc Rectifier," by Percy H. Thomas, of the Cooper-Hewitt Electric Company, New York.

February 14.—"Alternating Current Electric Traction," by Paul M. Lincoln, of the Westinghouse Electric & Manufacturing Company, Pittsburg.

March 14.—"The Wireless Transmission of Intelligence," by Lee de-Forest, Ph.D., of New York.

April 11.—"Recent Developments in Electric Lighting," illustrated by tantalum, osmium and other filament lamps; also by flaming arc and magnetic arc lamps, by C. H. Sharp, of New York.

May 9.—"The Development of an Hydraulic Transmission Plant," by F. A. C. Perrine, Sc.D., of New York.

Additional illustrated single lectures on the applications of electricity will be given under the joint auspices of the Departments of Electricity and Engineering, as follows:—

March 27.—"The Applications of Electricity in the Anthracite Coal Fields," by H. H. Stock, Ph.D., of Scranton, Pa.

May 16.—"Electric Propulsion on Trunk Railway Lines Having Terminal Stations in Greater New York and Vicinity," by a lecturer to be selected.

A course of six illustrated lectures on "Physical Chemistry," by Prof. Charles T. Baskerville, Ph.D., of the College of the City of New York, with special reference to the electrical side of chemical action.

Six illustrated lectures on "The Use of the Electric Current in Chemical Analysis and in the Preparation of Organic and Inorganic Substances," by Prof. Edgar F. Smith, Ph.D., of the University of Pennsylvania.

Six illustrated lectures on "Supersensible Radiations," or "Forms of Motion That do not Affect the Senses," by Prof. John S. McKay, Ph.D., of the Packer Collegiate Institute. The last three lectures of this course deal with electrical subjects, and the subjects of them are as follows:—

January 28.—"Electric, or Hertz Waves, and Wireless Telegraphy."

February 4.—"Cathode Rays and X-Rays."

February 11.—"Becquerel Rays and Radio-activity."

These lectures will be fully illustrated by experimental demonstrations.

Eight illustrated lectures on "Electricity," by Prof. Charles L. Harrington, M. A., as follows:—

April 6.—"Magnetism. The Electron Theory."

April 13.—"Dissociation and Ionization."

April 20.—"Electricity as Used in Some Chemical Problems."

April 27.—"Some Electrical Measurements."

May 4.—"Electric Lamps."

May 11.—"Wireless Telegraphy."

May 18.—"Radiography and the X-Ray."

May 25.—"Alternating Currents."

These lectures will be fully illustrated by experimental demonstrations and by lantern photographs.

Diesel Engines in Central Station Operation

At the recent convention of the Illinois State Electrical Association, W. J. Austin, manager of the Effingham Electric Light & Power Company, spoke of the results obtained with two 120-H. P. Diesel engines. Each of these engines drives a Fort Wayne 2-phase, 60-cycle, 2200-volt, 85-K. W. generator.

On a twenty-four hour run, the oil consumed was $15\frac{1}{2}$ gallons per 100 kilowatt-hours, the load varying from 12 per cent. to 85 per cent. of full load, with an average of 23 per cent. Oil costs 3.4 cents a gallon, so that the average cost of fuel was 0.542 cent per kilowatt-hour. On another test lasting six hours, with an average load of 70 per cent., 11.3 gallons of oil were consumed per 100 kilowatt-hours, making the cost of fuel 0.384 cent per kilowatt-hour.

The units are operated in parallel and no variation in the lights has been noticed. For speed regulation, a governor pump delivers the proper amount of oil to the engine cylinder to keep the speed constant. Compressed air is used in starting, one man requiring about two minutes for the operation. The enclosed crank cases are filled with lubricating oil, from six to eight quarts being required every twenty-four hours.

A rotary pump driven by a single-phase motor circulates the cooling water for the cylinder jackets. After coming from the engine the water circulates through 1000 feet of 2-inch pipe placed around the walls of the building. Except in zero weather this supplies enough heat for the building, which is 48 feet long, 32 feet wide, and 12 feet high.

The engines have been in operation only about eight months, and Mr. Austin could give no definite information as to the cost of repairs. The engines were put in operation Feb. 15 of this year, and had run twenty-four hours a day, exclusive of Sundays. During that time a shut-down had not been necessary. Three men are employed on shifts of about ten hours each, and are paid about $50 a month.

The General Electric single-phase traction system is to be used on the line of the Washington, Baltimore & Annapolis Railway, to be built between Baltimore and Washington, with a branch line from a point on the main line extending to Annapolis.

Electric Heating and the Residence Customer

By JAMES I. AYER

Quite frequently of late we have emphasized the growing importance of electrical heating devices as a means of adding to the day load of the central station and increasing the revenue. Anything said on this subject, however, would not be complete without a word from James I. Ayer, who may be looked upon as the dean of the electrical heating industry. His paper read at the recent convention of the National Electric Light Association is full of meat for the central-station man, and is instructive for all the electrical industries as showing the possibilities in the every-day use of current.—The Editor.

THE subject of electric heating, attracting, as it is, so much consideration to-day, offers little that is new in the way of additional development on the line of new appliances or new applications. This is not surprising when the past is considered, but how few realize the past of this industry is only appreciated by those who have been identified with its creation for a considerable period.

The first few years of development caused every possible application to be investigated, resulting in great variety of articles of common use requiring heat being arranged for electric heat,—many of which are catalogued, and many being set aside as being in advance of the times, but which will later on be found practical.

That there is an important, almost untouched, field for electric heating is now broadly recognized. How important it is and how advantageous to develop, is, the writer thinks, but little understood. Its character makes it largely a day load, and while it is of much value in its application in business establishments and factories, its most important field to the central station is with the residence customer.

The residence customer to-day pays the highest rate. To reduce this rate is most essential, for nothing goes further to check popular prejudice than personal consideration of the individual, and a reduction of rates to residence customers reaches a man in his home. Electric lights are used in the average dwelling because of their convenience and other well-known virtues partly, but largely to be "up to date."

It costs money to be up to date in most things, and if it costs a good deal more for the new than the old, we "kick." If it happens that a public service corporation is supplying the new, they have a common enemy to "kick," hence much of the trouble you are all familiar with. The residence customer demands the service, but cannot appreciate that it is the most expensive you give, and if you explain, he thinks you should find a way to cheapen it, or average your costs and reduce his rates.

Human nature doesn't believe in paying "something for nothing," and your minimum charge bill to him is paying "something for nothing." He does not understand that, though he uses no light, the transformer loss goes merrily on at your expense, at the rate of four or five dollars per year, and involves additional charges of nearly as much more, all directly created for his service, which would end if his service were discontinued. These facts have no influence with him. He only knows that the cost of his service is high by comparison with other, though less satisfactory, methods.

This situation, the writer thinks, is fully realized, and it is of vital importance at this time, with the public interest so much centered on corporations, that every means at your command be put forth to put you in closer touch with your customers and thereby let them realize that your corporation is a business enterprise managed by their neighbours, on the same general lines as all other honest, progressive business concerns in the community.

Electric heating offers an opportunity to quickly get in closer relation with more people in an effective way than any other means at your command, and if this be taken advantage of to the limit, more will be done to give the people a proper point of view on public ownership than volumes of statistics. By proper effort and systematic work persistently carried out continuously you can secure the introduction of electric heating devices in every home you serve.

The methods that may be used are numerous, and, from experience, we can with confidence make some definite statements.

The advertising methods are numerous in the way of using printer's ink, and much valuable and effective work is being done in this line, and it is understood that no effort to extend any business can have any measure of success without its liberal use. The space devoted to methods of advertising in the electrical press gives convincing evidence of an extraordinary interest in, and an exposition of, what is being done.

With an appreciation of the situation, it is with some diffidence that the writer presumes to outline a general plan for the average station so far as it relates to a method of extending the use of electric heating and other household devices using electricity. It has been well settled that more goods of any kind can be sold by personal presentation, and this is, in the writer's opinion, the only way to get the largest return and at the least cost. In all cases it is the only way to get the best results.

For the solicitors, use a customer's list for meter readers' routes, and make a card catalogue, divided into sections, and have circulars, or a typewritten letter with circulars, sent a few days in advance, announcing his proposed call and explaining the object. On each card a record can be kept which will be permanently valuable, as it will show when and what articles have been placed, to guide you in future efforts.

It is necessary to send out articles and leave them for trial after explaining fully how to put them in operation, and how they should be cared for, as well as to leave complete printed instructions which manufacturers usually send with each article.

The period of time an article should be left will be governed somewhat by the character of the device, but such an article as a flatiron would better be left thirty days, that ample opportunity be given to fully appreciate it. In the first instance of offering electric heaters it is better to allow enough time for trial to insure their thoroughly testing it, and to note the effect, if any, of its use on their bill.

Customers should be preferably called on at the expiration of a trial period to learn their conclusions. This is better than leaving or sending them a blank to sign, requesting you to send for the article or send a bill, as the case may be, because it is frequently the case that further interest has been developed, and other articles are wanted.

If your office be centrally located on the ground floor, and, of course, it should be, you should have arranged on shelves behind glass, and in the show-window, protected in the same manner, an assortment of samples and a few of the popular small articles as stock, so that if a customer is interested he can be supplied at once.

For newspaper advertising, small advertisements, frequently changed, but constantly maintained, are to be preferred, rather than occasional large ones; and newspaper advertising is desirable, though not to be substituted for the solicitor. For more extended methods in advertising, by circulars or otherwise with printer's ink, we will not pretend to guide you.

Exhibitions at food fairs and similar entertainments always prove to be leading attractions, and in that way do advertising, but direct results are usually few, and indirect results are difficult to estimate; considering the expense and attention required, it would generally seem better to seek other methods.

If it can be arranged, undoubtedly it is a good practice to invite your customers to a practical demonstration of the usefulness of electric heating and serve a light lunch, part or all of which could be cooked by the demonstrator.

The universal use of smoothing irons for many demands outside of the laundry makes this an ideal article for first introducing electric heaters. The success which has followed systematic efforts with this article is too well known to need further argument for its selection for such purposes. Thousands are used about the house other than for laundry work, and for such purposes the cost of operation is but a trifle.

For laundry use they are required from three to five hours a week, costing from 15 to, at most, 50 cents a week, the latter being for the longest period at a 20-cent rate. It is fair to say that at the average rate the average family ironing can be done at from $1 to $1.25 a month. With such results your customers will use laundry irons. If they do, they will not "kick" on minimum charge bills, because they will appreciate that they get something for their money.

Because of the quick appreciation of an electric iron you will be called on for other appliances, and by carefully keeping up your card index your solicior can be kept busy, as the demands from some will suggest what to push with others.

Using the flatiron as an opening wedge, you will do well to follow with circulars or folders describing such articles as water cups which will furnish a pint of boiling water in seven or eight minutes in the smaller size, or a quart in a larger size in ten minutes. Either will supply enough for a cup of tea in three or four minutes, and for shaving in less time. These articles are invaluable in the sick room, and for use in hundreds of ways. Improvements in these devices prevent their burning out or overheating in the event of boiling dry. This result is obtained by the circuit being broken automatically if the temperature rises a few degrees above the boiling point.

An electric heating pad can always be placed in a home where there is use for a hot-water bottle. Its superior merit is immediately appreciated on the briefest investigation. Aside from its usefulness in illness, it is much used by the aged as a foot-warmer. A naval officer told the writer that he had many nights walked the bridge with a pad under his coat, comfortable in bitter weather, in spite of side remarks about "a monkey on a string."

The nursery milk warmer performs its work by electricity more uniformly and perfectly than is possible with any other method and in a shorter time. An important feature is that the time required to heat it throughout to an even temperature is less than three minutes, making the period so short after the demand is made that peace is certain. Its operaation and sanitary character produce universal commendation from physicians. These devices are furnished with a socket plug arranged to receive the lamp which it displaces in the fixture, which is lighted when current is on the milk warmer.

Electric curling iron heaters are welcomed in many homes. For light cooking and the dining-room there are many useful articles. The chafing dish has many accomplishments to its credit. It can perform nearly all the operations of cooking required in homes, but, of course, in some cases not on the same scale as to quantity, and only one operation at a time, yet its possibilities are limitless when electrically heated. It can bake, boil, fry, stew and toast, is under perfect control, and always performs the same under like conditions, because its heat supply is a known quantity.

It is a simple matter to cook and serve a good American breakfast for three, of a cooked cereal, eggs, poached, boiled, fried, or scrambled, with toast, in thirty minutes with a chafing dish at the cost of 250 watts, and coffee can be made for 100 watts more,—a total of from 3 to 4 cents at the average residence rates. The stove which operates the chafing dish makes, with a kettle, a most desirable combination for the tea-table, and with a coffee percolator in place of the kettle, meets the requirements of the breakfast table.

Chafing dishes, tea-kettles and coffee urns can be had with heaters attached or separate in a variety of grades and designs, and there is no other method so safe, simple, or as cheap for performing similar service in the dining-room or kitchen, we current for performing any single operation with any of these devices is more often 1 cent or less than more, and never exceeds 3 or 4 cents.

For equally useful devices performing much the same work and more, in the dining-room or kitchen, we must remember that the water cups previously mentioned come in as a part of the list, because they can be used for making coffee or tea, or boiling of any sort. In one case the writer knows of they are used for cooking French-fried potatoes. This type of heater is also made to form a combination of double boiler or cereal cooker, egg boiler, steamer, as well as a plain boiler.

Disc heaters, or stoves with utensils, such as sauce pans, tea-kettles, coffee pots, cereal cookers, vegetable boilers, and the like, enable the housewife with, say, two stoves and two or three utensils, to do all the necessary cooking for light meals, in the dining-room if she pleases, within the limits of cost previously mentioned.

Realizing these facts, you must know that it only remains for your customers to know that they can do this to broadly extend their use. The writer has on several occasions made similar statements before, and some of you have profited by them, but many have not. Some say they are drawbacks, that you have tried electric heaters and they are too slow, that you cannot boil a pan of water in half a day, etc. To such, it did not occur to them that a 200-watt stove was hardly the proper size for a one-gallon open pan.

Quite recently the writer received a complaint that a stove purchased was worthless because it would not heat a glue pot, which investigation developed contained upwards of one gallon of water and glue, and the stove was one made for dentist's use to keep a glass of water warm. Stoves or disc heaters should always be supplied with utensils made for them of suitable proportions and with perfectly flat bottoms.

The above illustrations and explanations are given to remind you of the necessity of learning about electric heaters, their limitations, as well as their good qualities, and the difference between temperature and heat. The difference between the application of electric heat and other sources of heat is not difficult for anyone to understand, and that quickly, but there is a difference, and for best results must be understood.

Imagine how complicated the operation of the various gas appliances would be to one who had never seen them. If they will blow it out, how would a gas range appeal to them?

The importance of thoroughly acquainting yourself with each different item by carefully reading the manufacturer's instructions and explanation, then having them put in operation under the working conditions they are designed for, is essential to those who propose to place them with their customers, and cannot be too much emphasized. Take all of the articles into your own homes and give your solicitors some similar opportunity, and you will get results.

The popular articles referred to are what you should concentrate your efforts on until material results are accomplished, but during such period you will have demands for cooking outfits, kitchenettes, or ranges for all the kitchen requirements, as well as water boilers for the kitchen, heaters for bath water, and radiators, all of which you will occasionally find opportunity to place to advantage.

For general cooking, there are available individual cooking devices in all sizes required for the largest household, also ovens, plate warmers, broilers, griddles, waffle-irons, frying kettles, and the like.

Demands for general cooking will be to fill the place now occupied by gas stoves, which, except in apartment houses, are largely summer workers. Considering, for the present, those cases where the principal use is in summer, it is customary when using gas stoves to operate the coal range one or two days each week for supplying hot water for washing and the bath, and, of course, cooking at the same time. This reduces, in many cases, the demand for service to perhaps six days each week, and in considering the subject the probable practice should be an element.

Experience has shown from a great variety of sources that the number of watts per meal per person may safely be taken at 300, or 900 watts per day per person. If, however, we allow one kilowatt-hour per person, we have thirty kilowatts for a month, which, at a 5-cent rate, is $1.50, or, for a family of four, $6 per month; or at a 3-cent rate for the same family, $3.60 per month. While these rates are absurdly low to-day for lighting rates in residences, there are many cases where the service may be given from separate service wires at a satisfactory profit.

By careful comparison, it has been determined that in cooking, an equivalent cost for $1 gas is 2½ cents per kilowatt-hour, and while electric cooking is widely practical at a higher rate, it will demand from 5 to 3-cent rates to make it an important competitor to gas. Gas, however, occupied a broad field at a much higher price than coal, due to its advantages, and electric methods make it possible for you to secure equal results because of the many advantages possessed by the newer method over the old.

For heating the general water supply, a kitchen boiler of the usual type is used, varying in capacity from ten to thirty gallons, and supplied preferably with a heater contained in the boiler of a maximum of 2000 watts, that may be reduced to 1000 or 500 watts by a controlling switch. Such a boiler should be jacketed with ordinary pipe covering, and, with care, is not necessarily an excessively expensive luxury. A ten-gallon boiler can be heated to 150 degrees F. with approximately 2½ KW., which will answer a very considerable demand throughout the day from a jacketed boiler of that capacity.

For bath water, heaters are supplied to be placed in the tub. Those with 2000-watt capacity are frequently satisfactory to those who understand in advance that it requires 2000 watts for an hour to raise 20 gallons of water through 40 degrees F.

Radiators for occasional use in bedrooms for short periods are practical and useful, but should have a capacity of not less than 1000 or 1200 watts to be at all effective, and, except in the case of small rooms, they should be larger. For heating the bathroom, many radiators are sold which, to be effective quickly, should have 2000 watts capacity. Of this size, if turned on for fifteen or twenty minutes, they fully accomplish their purpose, and are not expensive to the owner.

The instantaneous hot water heater, to be practical, requires that current supply of 3000 watts and more is available. While for small quantities the cost of operation is not excessive, the service demand is undesirable, and it is expensive to install. As small water heaters are so much more simple and easy to supply, they meet the demand for small requirements.

In referring to water heating and radiators, the writer appreciates that the field in any community, with rare exceptions, is very limited, yet the sale of these devices reaches a very considerable sum annually, and is daily increasing.

The service for a family kitchen for the average family for cooking should have a capacity of about 3000 watts, and if a kitchen boiler, bath water heater, or bathroom radiator is to be included, a double-throw switch can be installed in the kitchen or other convenient place so connected as to throw off the boiler, radiator, or bath circuit when the cooking circuit is required, and to avoid the necessity of extra large service capacity which would otherwise be necessary.

This also suggests a method of limiting the hours for cooking service to a period when lights are not required; but it has objections, although it is practical.

The cost for heating water to different temperatures at different rates is given on the next page. This table tells best what is required in current supply for a given result in quantity, temperature, and time as well.

The writer's judgment is that the policy to pursue is to personally press the sale of small household devices constantly, without complicating the situation by trying to interest customers with the larger problems, until from experience with the smaller, they have become prepared for further ventures.

During such a period you should gain practical experience in the larger problems in your own home, and you will find customers who will insist on complete equipments at such rates as you can make, and from these sources you can gain the additional knowledge to govern your future policy. The small devices will earn from $1 to $2 per month, which will cover present transformer losses and leave a profit, and the satisfaction of your customers with their use, coupled with the advantages gained by your personal interest in them, will more than justify all your efforts.

When business depression comes, one may cut off his electric signs, but not likely a house service, which provides many conveniences besides his light. The writer is sure that those who have followed the policy outlined can endorse these suggestions. That there is a large army of managers who have only begun to seriously consider this subject is the writer's excuse for going over much the same ground as in a paper on this subject at the Boston convention.

The writer has confined his remarks to the development of electric heating with residence customers, not with the thought that you should neglect the fertile field among manufacturers and merchants, but to impress on you the importance of the small consumer, believing it to be the most direct way of creating a widespread interest in a branch of electrical development which has a possible application with practically every customer on your lines. If it is practical in his home it will suggest its use in his business, and his demands can be met.

INITIAL TEMPERATURE OF WATER, 60 DEGREES F. EFFICIENCY OF APPARATUS, 85 PER CENT.

One Pint

Total Temperature, Degrees F.	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100	164	82	41.04	13.68	.041	.068	.136	.272
150	372	186	93	31	.093	.155	.31	.62
175	468	234	117	39	.117	.195	.39	.78
200	576	288	144	48	.144	.24	.48	.96
212	624	312	156	52	.156	.26	.52	1.04

One Quart

Total Temperature, Degrees F.	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100	324	162	81	27	.08	.136	.272	.544
150	744	372	186	62	.186	.31	.62	1.24
175	936	468	234	78	.234	.39	.78	1.56
200	1,152	576	288	96	.288	.48	.96	1.92
212	1,248	624	312	104	.212	.52	1.04	2.48

One Gallon

Total Temperature, Degrees F.	Watts Used for 5m.	10m.	20m.	1 Hour	Cost in Cents with Current at 3c.	5c.	10c.	20c.
100	1,296	648	324	108	.32	.544	1.088	2.17
150	2,976	1,488	744	248	.74	1.24	2.48	4.93
175	3,744	1,872	936	312	.94	1.56	3.12	6 24
200	4,608	2,304	1,152	384	1.15	1.92	3.84	7.68
212	4,992	2,496	1,248	416	1.25	2.08	4.16	8.32

New Forms of Incandescent Electric Lamps

SOME of the new forms of incandescent electric lamps are described by Dr. C. R. Boehm, in the "Journal für Gasbeleuchtung und Wasservesorgung," an abstract being given in "The Illuminating Engineer" of recent date.

The Uviol lamp is so called from the glass used, namely, uviol (ultra-violet), produced by Dr. Zschimmer, of Jena. This glass has the property of allowing ultra-violet rays to pass through it.

In order to develop the ultra-violet radiations for more general purposes, it was necessary to make the apparatus and its use more accessible, as in the Hewitt lamp. Since ordinary glass does not let the ultra-violet rays pass, but absorbs them, it was necessary to seek another medium, and molten rock-crystal was first experimented with.

Mercury lamps were thus made from quartz glass by W. C. Heraeus, in Hanau, which caused a sensation among scientists in 1905. The strong smell of ozone surrounding it indicated the wide extension of ultra-violet rays produced by them, which reacted on the oxygen in the air. The high price of rock crystal and its manufacture, however, obstructed its general use for mercury lamps, especially for medical purposes.

With Dr. Zschimmer's glass compound Uviol, improvements were made on the mercury lamp that satisfy all expectations, scientific as well as practical.

It is expected that photography will profit by this source of light on account of the innumerable short waves. In chemistry also it is likely to be used for causing two substances to combine, similar to the action of sunlight on chlorine and hydrogen to form hydrochloric acid. The bleaching action of the rays will also afford a means for testing colours.

The rays of the Uviol lamp kill the smaller insects,—not by heat, however, as was shown when a fly was killed within a minute when brought within a half inch of the lamp. Microbes were also killed under its influence.

But the most important and most interesting application of the ultra-violet light is in the treatment of skin diseases. Since Finsen's sensational treatment of lupus, violet light is acknowledged as one of the most powerful cures. But the high price of an apparatus that produces this light, and the difficulty in handling it, hinder its general application; this is true especially in the concentrated carbon light of Finsen. Since his results were published attempts were everywhere made to substitute the Finsen apparatus with a smaller and cheaper one, but until lately without success. The iron light, richer in short-wave rays than the carbon arc light, is only superior in superficial effect, but far inferior where a thorough effect, that depends on the abundance of the blue, violet and ultra-violet rays, is required.

Progress in the treatment with light depends on a simple, cheap and convenient light-source, the effect of which is not only equal to the Finsen light, but even superior to it; the special mercury lamps of Heraeus and Schott (Uviol lamp) are light-sources of this kind. The advantages of these lamps are:—(1) Shorter duration of treatment; (2) treatment of larger areas; (3) treatment of mucous membranes; (4) no hurrying; and (5) cheapness on account of small current consumption, etc.

The lamp constructed by Dr. Schott, called the fluorescence lamp, and lately exhibited at the convention of scientists in Meran, is simply a kind of Uviol lamp, modified in such a way as to suppress and avoid a great part of the long wave rays; for that reason it gives no bright illumination, while the outside and arrangements are the same.

All objects in the light of these lamps appear indistinct and blurred; though it is dark it causes on all kinds of substances surrounding it a general fluorescence, as, for instance, on rhodamin, fluorescin, and uranium glass, causing these substances to shine brighter than the lamp itself. Vaseline, lanoline, soaps and the human skin show a peculiar play of colours. Since in the latter case in daylight changes of the skin are made visible, we possess in this lamp not only a highly valuable means for therapeutical and pathological purposes, but also for diagnosis.

This fluorescence of the lamp,

which naturally has an extraordinary value in physics, will undoubtedly be used also for treatment by the so-called sensitizing of light by means of fluorescent solutions, which are now used to a considerable extent in medicine. All these actions are explained by the chemical action of the ultra-violet rays.

In working with ultra-violet rays it is necessary to protect the eyes by means of eyeglasses in order to prevent a violent inflammation. More than fifty years ago it was the opinion of the French scholars, Regnault and Foucault, that the violet and ultra-violet rays are injurious to the eye, because they excite its fluid to fluorescence, tire the nerves, and change the transparent texture.

Since the peculiar colour of the light produced by the Hewitt lamp was the greatest obstacle to its general use, efforts have been made to remedy this defect. This objection has been met in the so-called Orthochrom lamp by putting ordinary electric incandescent lamps in the circuit, or by changing the mercury waves into red waves by the fluorescence of rhodamin. The latter process means a loss of light of 25 per cent., but, so far, they have been used, on account of their extraordinary actinic powers, for photographic purposes only. The most valuable property of the Hewitt lamp is the possibility, as Mr. Hewitt pointed out, of transforming alternating currents into continuous currents.

Many experiments have been made to substitute other metals for mercury, but never with success. The volatilization and condensation of the negative electrodes is too difficult in the case of other metals; nor have any good results been obtained by the use of other gases with mercury electrodes.

Moissan has lately proved that the metallic oxides, that were thought to be unchangeable, may be decomposed by high temperatures. Reactions that were incomplete at the temperatures of the ordinary furnace were much more complete at the temperatures of the electric furnace. Many compounds are broken up at these high temperatures, and others, until recently unknown, are produced in a well-established and stable form, as carbides, boricides and silicides.

Attempts to reduce all metallic oxides by means of carbon in the electric arc lamp resulted in well-defined compounds of carbon with the metal, forming carbides. The metallic carbides may be divided in two classes: the one is soluble in water, the other very stable. To the latter class belongs zirconium carbide, which is now used in the manufacture of incandescent lamp filaments.

According to the patents taken out by Sander, zirconium incandescent mantles are made from the hydrogen or nitrogen compounds of the rare earths, especially of zirconium, with the aid of an organic binding means. To obtain these compounds the zirconium earths are reduced by magnesium, according to Winkler, in a current of hydrogen or nitrogen gas (in practice the hydrogen current alone is used).

In contradiction to the analytical results of Winkler and Bayle, we should obtain the pure hydrogen compounds, if we work, according to the patents, with a surplus of magnesium metal and the addition of heat from an outside source. According to Hollefreund, the figures of the analysis give the formula ZrH_4. To remove the magnesia and the residual magnesium the reduction product is dissolved in a weak solution of hydrochloric acid, dried, and then worked to a paste by means of a binding menstruum. It is best then to heat the thread obtained by pressing to about 300 degrees in an atmosphere of hydrogen after it has been dried, in order to avoid oxidation.

The threads possess a very low conductivity, so that they have to be submitted to high currents in a subsequent treatment afterwards in the recipient or they have to be heated. In the latter case the ordinary voltage makes the thread glow, and it will always be a conductor because carbide formation has taken place. Then by means of a hydrogen current and gradual increase of voltage the thread is caused to shrink. As the voltage increases the thread changes its structure, becomes hard and metallic in appearance, and its electric qualities resemble those of a metal. According to Weddings, such incandescent lamps burn at 2 watts per candle, and are suitable only for low voltages.

The zirconium carbon lamp consisted of ordinary carbon thread having on the surface a thin layer of zirconium metal in place of the graphite coating. Lately an improved zirconium lamp is sold that is supposed to burn with 1 watt per candle.

The name implies that it is a lamp analogous to the osmium and tantalum lamp. According to the description of the recent patents, it is a carbide lamp in which the percentage of carbon is decreased by suitable additions and processes.

The carbides of all metals, including that of zirconium, have long been used for electric incandescent lamps. But only by adding other metals of high melting points, as, for instance, Wolfram and ruthenium, zirconium filaments could be made, the melting point of which lies higher than that of the zirconium carbide filament.

Such lamps burned, according to Bojes, with 0.6 watt over 120 hours, and, at 1 watt per candle, for 1000 hours, showing in the first 500 hours almost constant values. The length of the thread is, for a thickness of 0.02 inch, about 0.195 inch for 1 volt. The later zirconium lamps are especially suitable for low voltages, but, by connecting several incandescent filaments in series in one lamp, we may obtain incandescent lamps for voltages as high as 110 and 220. The new zirconium-carbide lamp is, therefore, arranged with three filaments for 110 volts.

Along with the improved zirconium lamp an iridium lamp made its appearance lately. Iridium, like osmium, belongs to the platinum group, and was mentioned as early as 1878 by Edison as applicable to electric incandescent lamps. Iridium is extraordinarily hard and brittle, and non-malleable. It can be rolled to a thickness of about 0.0312 inch. Gulcher applied it in the manufacture of incandescent lamp filaments, and as nothing is known about it, it may be interesting to give here the description of the patent:—

"A process of making thin and uniformly dense incandescent lamp filaments from pure iridium, in such a way that threads are made of iridium in a very finely divided condition, from which the binding means is completely removed by heating in the air, and dried in the air in a moderately high temperature. They are then strongly heated in the open air until they shrink completely together."

Again: "Process for the production of thin and uniformly dense incandescent lamp filaments made from pure iridium according to the above, in which iridium ore is thoroughly mixed with the combining means, the thread formed from the stiff and plastic mass passed through a current of hydrogen, after drying, in order to reduce the oxide still contained in the iridium ore to metallic iridium, and then heating the thread, consisting only of metallic iridium and the binding mass, to the highest white heat in the open air."

The iridium lamp is, like the osmium lamp, meant only for low voltages, and not to be regarded as a serious rival of the carbon incandescent lamp, because iridium and osmium occur rarely in Nature.

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Leading Articles

Seeing by Electricity

WITHIN the past few weeks two inventors have announced, independently of each other, the completion of a device for seeing at a distance by electrical means. An illustration of one of the inventor's instrument, appearing in one of the electrical journals, shows a woman speaking into the ordinary telephone transmitter and holding a receiver to her ear, while to one side of the transmitter is a cone-shaped projection purporting to contain within it the device for reproducing the distant picture.

Four wires are used at present, so runs the description, but these will eventually be reduced to two. Natural colours are said to be reproduced. With the usual secrecy attending the introduction of such a marvellous device, details of its operation are withheld. No opinion can, therefore, be expressed as to whether the claims of the inventors have been substantiated.

This is not the first instance of a solution being sought for the problem of seeing at a distance by means of the electric current. Men well fitted to attack the problem have done so in the past, but without success. It is not so long ago that M. A. Nisco, of Belgium, essayed the task. After a study of many of the proposed methods, he concluded that none of them would be feasible. Many of these methods depended for their operation on that property of selenium by which its electrical resistance varies as the intensity of light thrown upon it.

As a result of Nisco's study, he believes that a system constructed on radically different lines would give practical results. This system, as described by Wm. Maver, Jr., in a recent issue of "Cassier's Magazine," is as follows:—

Let a sensitive screen be prepared by coating a metallic net with an insulating varnish. Into the meshes of the net copper wires are inserted before the insulating material hardens. The surface is then filed off smooth and a coat of selenium is spread over the net, this forming a connection between the net and the copper wires. The selenium is then treated in such a manner as to crystallize it, which brings it into the required sensitive condition.

The copper wires are led into a hollow ebonite cylinder and are then brought to the outer surface of the cylinder through holes that are arranged to correspond to the position of the copper wires in the netting. The holes are arranged in spirals around the cylinder, and a steel blade is caused to pass around the cylinder at the rate of 600 revolutions a minute. As it does so, the blade makes momentary contact with the protruding copper wires, ten times per second. The blade, the copper wires and the metallic screen are in an electric circuit with a battery and a telephone receiver. To this telephone is connected a minute microphone which repeats the variations of current that may be set up in the selenium circuit into the transmission line.

At the receiving station a second telephone receiver, by means of another suitably arranged microphone, repeats the variations of current into a local circuit, which is arranged to produce a spark, the luminosity of which depends on the strength of the current, which latter, in turn, varies directly with the intensity of illumination at the selenium screen at the transmission station.

The spark-gap is placed within a cylinder which is provided with slots arranged spirally around the cylinder in a manner corresponding to the arrangement of the copper wires in the transmitting cylinder. The slotted cylinder revolves in unison with the blade at the sending station.

If then, says Mr. Nisco, a picture be thrown upon the metallic screen while the apparatus at each station is operating synchronously, the light of each spark at the receiving station will be cast on a receiving screen in a manner capable of producing an illuminated image of the picture at the transmitting station. The method just described produces only variations in illumination, and it requires two wires, one for maintaining synchronism between the moving apparatus, the other for transmission of the variable currents.

While Mr. Nisco's plan thus outlined does credit to his ingenuity, its practicability appears rather problematical. It is not altogether unlikely, however, that Mr. Nisco's suggestions have formed, and will form, the basis of the efforts of numerous aspirants for fame and wealth in this direction. The public, however, should take all statements of successful accomplishments of this nature with a grain of salt.

Recent Incandescent Lighting Progress

SINCE the commercial production of the single-phase railway motor the most striking advance in the electrical field has certainly been made by that most familiar of all electrical appliances—the incandescent lamp. The recent production of 50-watt metallized filament lamps having an efficiency of 2.5 watts per candle power (mean horizontal) and a useful life of 500 hours marks a notable step forward, for, valuable as the higher candle-powered high-efficiency units are in the larger illuminating work of the present day, it remains for the ordinary 16 to 20-candle-power lamp to meet the requirements in the great majority of installations.

In a paper on "Recent Incandescent Lamp Improvements" presented in September before the Vermont Electrical Association at St. Johnsbury, Mr. Francis W. Willcox, of the General Electric Company, pointed out a number of significant signs of the times in the lighting field. By reason of its great simplicity, moderate cost, ability to withstand the most abusive conditions as to surroundings, divisibility into small units, noiselessness of operation, reliability and æsthetic attractiveness, the incandescent lamp is almost an ideal piece of apparatus. In the average case it will certainly have the preference for illuminating work at equal or better efficiency, and with the recent progress in economy for a given production of light, we can expect the proportion of central station income from incandescent service will be materially augmented, the field widened and the volume of business greatly increased. The investment required for arc lamps is relatively high; small units are unsatisfactory; the limit of frequency is about 40 cycles, and for a. c. and d. c. circuits two types of lamps are required. Even the Nernst lamp is available for alternating current only, in this country. The numerous moving parts of the arc lamp require attention and adjustment while in service, which is of course not the case with the incandescent.

The prices of high-efficiency lamps complete with reflectors are now sufficiently low to bring the renewal costs about on a parity with those of the old 3.5 or 3.1-watt lamp, hence these lamps can be supplied on the same liberal free renewal basis as ordinary lamps, and many companies have adopted this policy with advantage. In the effort to improve the distribution of light by the use of scientifically designed reflectors—and this is quite as important as the production of more efficient filaments—a new Holophane "Bowl Reflector" has been brought out, which gives uniform illumination over an area equal in diameter to 1.5 times the height of the lamp above it, giving a distance between lamps for uniform lighting of 2.5 times the height. Results like these are nearly ideal, as the curve of distribution corresponds very nearly to the perfect curve of uniform illumination. In comparison with the 50-watt lamp of 3.1-watt efficiency, the new 50-watt 2.5-watt efficiency lamp shows a gain of 20 per cent. in economy and of 350 per cent. in life for the same efficiency. One must consider the long years of painstaking, plodding work required to increase the useful life of the old carbon filament 100 hours, or about 25 or 30 per cent., to realize what progress the new filament has made. In the case of series lamps of low voltage the improvement in life for the same efficiency is about 500 per cent. With such a gain—practically 1 watt per candle-power for equal life—the high-efficiency series lamp should be able to compete on very favorable terms with the Welsbach, which is such a serious competitor for suburban street lighting, on account of the better value of small and more frequently placed units of light for this class of service.

In the case of the tantalum lamp, the change of resistance with respect to change of voltage gives a more favorable condition than for the ordinary carbon filament in respect to the effects of fluctuating voltage upon candle-power and life. It requires nearly twice the per cent. change in voltage on the tantalum that is does for the carbon filament, to produce the same change in candle-power. The tantalum lamp has a useful life of about 700 hours on direct current, but only about 200 on alternating circuits. It does not seem possible to reduce the size much below 22 candle-power without a sacrifice of efficiency below 2 watts per candle. Thus the 16-candle-power lamp of tantalum filament has an efficiency of about 2.25 watts. The lamp burns to best advantage with a suitable reflector, and in a pendant position. It has a useful life 40 per cent. longer than the 3.1 or 2.5-watt filaments, on d. c. circuits, costs about three times as much as the 3.1 lamp, 2.4 times as much as the 2.5-watt lamp, or about 50 cents net, dating from Sept. 1. Unfortunately it is somewhat fragile, and suffers from vibration. Even with this slight disadvantage, it should compete with a Welsbach mantle, if the price of the present incandescent lamp is allowed toward a new tantalum.

Mr. Willcox did not discuss the new tungsten lamp at St. Johnsbury, and in view of the announcement that this lamp is new on the market, it should not be overlooked in considering the latest progress in the incandescent field. It is reasonable to expect an efficiency of from 1.5 to 2 watts per candle-power with the tungsten filament, although a number of points remain to be definitely determined by commercial experience with this type of lamp. It is something of a question just how well the tungsten lamp will work on both a. c. and d. c. circuits. The most suitable candle-power for various efficiencies are as yet undetermined in the minds of lamp users, but if reasonable first cost and life can be guaranteed, there is little doubt that the ordinary carbon filament will be generally superseded, particularly as tungsten is not one of the specially rare elements. Whether central stations are disposed to supply their customers with high-efficiency lamps or not, the consumer will certainly procure them sooner or later, so that there is little to be gained in refusing to follow the epoch-making advances of the past two years.

A great deal of misunderstanding has occurred in certain central stations in connection with the introduction of high-efficiency lamps. There has been a fear expressed in some quarters that the central station business would suffer by the adoption of improvements which primarily benefit the consumer. A broader view than this should obtain. The central station does not give the consumer more electrical energy for the same money by adopting the high-efficiency lamp; it simply gives him more and better light for the same monthly bill. It is often hard for a central station man to realize that light is what his customers desire, instead of so many kilowatt-hours by the meter. Then, too, the new lamps cannot be turned out fast enough to demoralize existing conditions. The slightly increased cost is a small matter in the face of the increase of business which ought to follow the late improvements in incandescent lamp designs. There is no need to wait for still further advances before taking hold of present gains, for the incandescent lamp is a relatively short-lived piece of apparatus.

Taking Care of the Central Station Customers

In this issue, a number of articles and papers read at recent conventions deal more or less directly with the attitude of the central station man toward his customer.

In describing the business-getting and business-holding methods adopted by the Denver Gas & Electric Company, Frank C. Farrar tells elsewhere in these pages of the use of "service supervisors" and "young women inspectors" for getting new business and keeping it. There can be no doubt that this feature will be a large factor in promoting the good feeling between company and customer, and is, therefore, a valuable one aside from the increased revenue obtained by it.

The value of anything which conveys the impression to the central station customer that the company has an interest in the successful and economical use of his lights or heating devices, is perhaps underestimated by some. Bad service, indifference on the part of the company, a "public-be-damned" policy, or, as pointed out by Mr. Blood in his article on "The Corporation and the Public," passivity under hostile attacks, all contribute to the growth of the municipal ownership idea.

Perhaps next to direct antagonism, the most harmful attitude of the central station manager toward his customer is one of indifference. It has been said before, but it will bear repeating, that the central station manager is a merchant with goods to sell, and the well-known rules of salesmanship are as necessary in selling current as in selling hardware or dry goods.

After all that has been said, written and done about and in business-getting campaigns, it seems surprising that anyone having current to sell should be not yet awake to the possibilities which the field offers. And yet, after reading the paper by H. K. Mohr, reprinted elsewhere in this issue, one cannot but feel that many have yet to see the light. A good deal has been said about educating the public. It appears in some cases to be of greater moment to educate the central station manager in a systematic, persevering campaign for educating the public.

Engineers' Commissions

In an address on "Professional Ethics," delivered by Dr. R. W. Raymond, secretary of the American Institute of Mining Engineers, to the graduating class of Lehigh University, he made the following reference to the acceptance by engineers of commissions on purchases:—

"Perhaps the commonest question of casuistry occurring in modern business is that of commissions. As the agent of your employer, you have to purchase a steam engine. After getting the prices and inspecting the engines of all the manufacturers, you decide upon the machine most suitable, on the whole, for your purpose, and in all legitimate ways beat down the sellers thereof to their lowest price. Just as you are about to close the bargain at the price, they say, 'This covers, of course, your commission of 10 per cent.' When you reply that you do not expect any commission, and suggest that, instead of paying it to you, they take it from the amount of the bill they send to your employers, they tell you that, according to some trade agreement, they cannot charge a lower price, but can pay a commission to the selling agent. Now, you are not the selling agent, but the purchasing agent, and, explaining this difference to them, you tell them that you will be in honour obliged to pay your employers whatever commission may be paid you. To this they reply, with a kindly, but cynical smile, that they do not care what you do with the money after you have got it, and you see clearly that they regard your protestations of honour as part of the formula which precedes your acceptance of the money. They do not really believe that you will not keep it if you get it.

"I am repeating an episode of my own experience, and perhaps my solution may be of use to you. I declined the commission offered in currency; required it to be put in the form of a check to my order; indorsed that check to the order of my employers and presented it to them, leaving them, if they saw fit, to return it to me as a legitimate perquisite of my position. They did not see fit, and they were quite right. But the most important feature in my action was that the return of the check, thus indorsed by me in their favour, convinced the manufacturers of my honesty as no amount of high-toned oratory on my part could have done."

Electrical Equipment for the Hudson Companies' Tunnels

Work on the electrification of the twin tunnels of the Hudson Companies, connecting Jersey City with New York under the North River, is now under way. Fifty electric cars will be operated, taking their power from the third rail. Each tunnel will have a single track, the north tube carrying the west-bound traffic and the south tube carrying the east-bound or New York traffic.

The cars will be operated in trains by the Sprague-General Electric system of multiple unit control in a manner similar to that employed on the New York subway trains. Each car will be equipped with two 160-horse-power railway motors.

Power for this new development will be supplied from a large station on the New Jersey side, located between Jersey City and Newark. Curtis steam turbines will be employed, the initial equipments including two 3000-kilowatt, 11,000-volt machines and two 6000-kilowatt, 11,000-volt machines. The total power so generated will be distributed at high voltage to three sub-stations where the alternating current will be stepped-down to 650 volts, direct current, through transformers and rotary converters.

The sub-stations will be located as follows:—Sub-station No. 1, Greenwich and Christopher streets, New York, containing five 1500-kilowatt rotary converters and fifteen step-down transformers; sub-station No. 2, Washington and First streets, Jersey City, containing four 1500-kilowatt rotary converters and twelve step-down transformers; and sub-station No. 3, Cortlandt and Church streets, New York City, containing two 1500-kilowatt rotary converters and six step-down transformers.

Each sub-station will, in addition, contain one spare 1500-kilowatt transformer.

It is expected that the running time between the various suburban cities of New Jersey and New York City will be reduced one-half.

The Effect of Load Factor on Cost of Power

By E. M. ARCHIBALD

A Paper Read at a Recent Meeting of the Canadian Society of Civil Engineers

THE great desideratum for an electrical system is a high load factor with consequent greatest return on investment, load factor being the ratio of average to maximum load. All the factors of expense included in cost of power to the consumer are then operating at maximum economy, and cost of power is at a minimum.

The lighting of residences and offices produces a peak in the late afternoon and evening, with but little load the remainder of the twenty-four hours; consequently, the average load on the plant with lighting only is very small and the load factor low. A commercial motor load in connection with lighting will increase the average load even though causing a greater peak.

The addition of a street railway load still further increases the day load, but in consequence of the heavy demand load during the rush hours, when the public is going to and from business, which occurs at the peak of the lighting load, the peak load on the plant is greatly increased. This heavy peak, with but a small average load over the twenty-four hours, produces a low load factor, and a portion of the machinery being shut down the greater part of the time, higher rates must be paid by the consumer to secure a certain return on first investment than when the load factor is higher.

Evidently, when the load factor is 100 per cent.—that is, when the load is constant throughout the twenty-four hours, and all the machinery is in continuous operation—the cost of power per kilowatt-hour is a minimum, and the greatest return on investment is realized. Customers having a steady load or with high average load are greatly desired and may be offered much better rates than all others. It will be the endeavour of this paper to determine the decreased cost of power with increasing load factor.

The storage battery is evidently a means in the hands of the power producing company of increasing the average load on the machinery. By charging the battery during light load and discharging during periods of heavy load, a more constant load on the generating apparatus is produced, with consequent better efficiency, and, at the same time, acting as a reserve in case of accident in the power plant.

Unfortunately, the battery is expensive, and a loss occurs in its operation which greatly reduces the higher efficiency secured by the increased load factor. The great benefits obtained by its use are reserve capacity and voltage regulation, enabling the use of more efficient lamps.

The storage battery, however, has not been considered in what follows, even where it might be desirable, but rather a plant is assumed of certain maximum capacity for the peak load, and we are to determine what effect various load factors have on the cost of power produced.

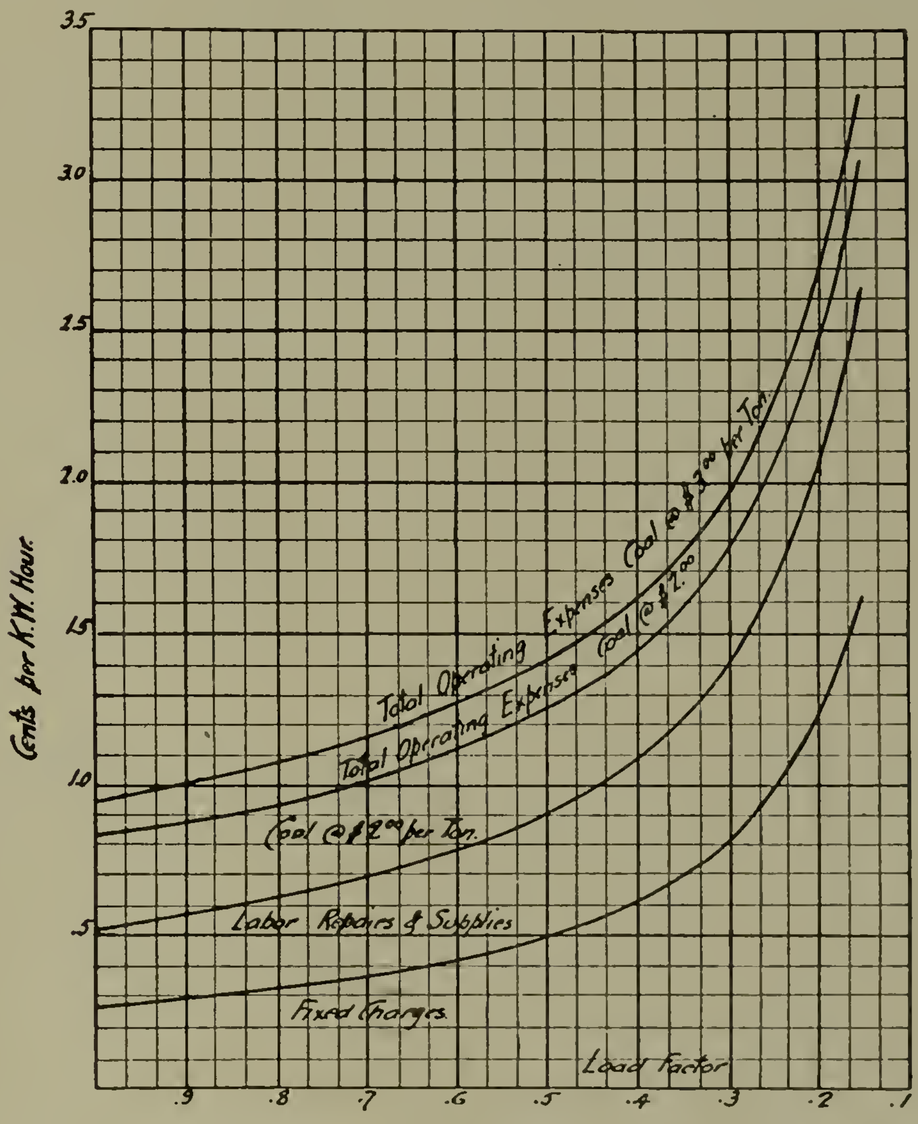


FIG. 1.—OPERATING EXPENSES OF A 900-KW. CONDENSING STEAM PLANT WITH A 750-KW. PEAK

The various expenses involved in the cost of power to the consumer are as follows:—(1) management; (2) distribution; (3) production.

For a given system with given peak load the cost of management is practically constant, no matter what the load factor.

The cost of distribution is constant with various load factors, so far as the fixed charges and maintenance are concerned. The losses in distribution, however, vary, these consisting of losses in lines, in transformers if alternating current be used, in meters, losses in grounds and losses from theft of current; all decrease the output and accordingly increase the cost to the consumer.

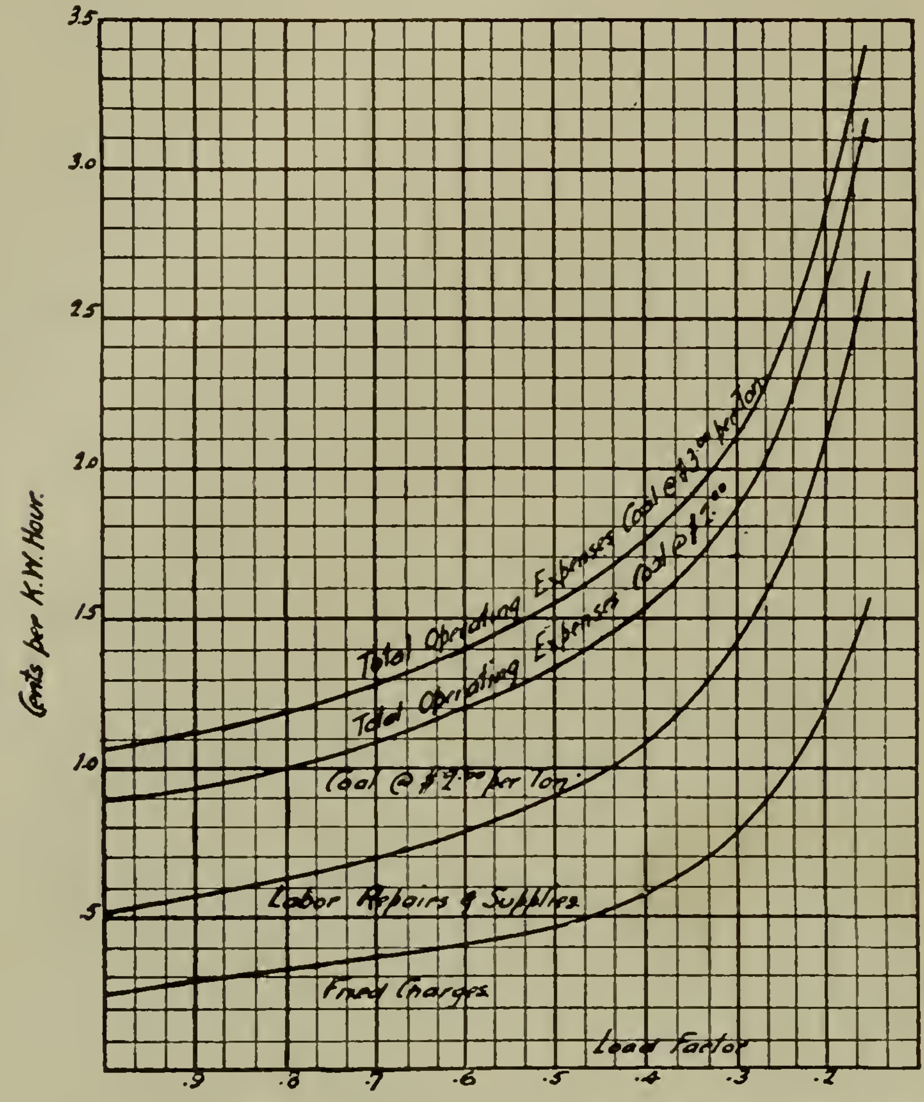


FIG. 2.—OPERATING EXPENSES OF A 900-KW. NON-CONDENSING PLANT WITH A 750-KW. PEAK

While it is possible to determine fairly accurately the losses in lines, transformers, and meters with varying load factors, the losses from grounds and theft are indeterminate and require constant attention to keep them within certain limits. Yet, as a rule, these will become a smaller percentage of the total output the higher the load factor.

There yet remains for consideration the effect of the load factor on the actual cost of production of energy. The higher the load factor, the greater is the amount of power produced, the longer does the apparatus operate most efficiently, the lower the ratio of fixed charges to total operating expenses, and consequently the lower the cost of power per unit.

To determine exactly in what proportion the cost of power is decreased, it will be necessary to assume a plant, determine the fixed and variable charges, and thereby the cost per kilowatt-hour at various load factors.

Let us take, for example, a plant with a peak load of 750 KW. Allow three units of 300-KW. capacity each, so that in case of a breakdown to one, the other two may take care of the peak with an overload of 25 per cent. on each, and sufficient boiler capacity for the same contingency. No provision is allowed for stokers, coal handling apparatus, or economizers. The plant is assumed to be on the water-front, providing sufficient water for condensing purposes.

Curves are also plotted for a second plant of the same capacity as the first, but operating non-condensing. In both cases either water or railroad connections are assumed, with convenient facilities for coal handling and removal of ashes.

FIRST COST OF PLANT COMPLETE

Condensing, $118,425, equivalent to $131.60 per K. W.
Non-condensing, $114,625, equivalent to $127.40 per K. W.

Fixed Charges	Condensing	Non-Condensing
Interest at 5 per cent....	$5.921.25	$5,731.25
Taxes and insurance at 2 per cent.	2,368.50	2,292.50
Depreciation machinery, 10 per cent.	7,710.00	7,305.00
Building, 3 per cent......	1,122.00	1,134.00
Totals	$17,121.75	$16,462.75

The above first cost being for 100 per cent load factor, there will be a varying reduction due to the decreased boiler capacity required on lower load factors. A point is reached below which it is not advisable to further decrease the boiler capacity, as the peak load must be taken care of and sufficient reserve provided for accidents and repairs, this point being taken in this case at 40 per cent. load factor. The effect of this reduction is to diminish the fixed charges at 40 per cent. load factor by $1000 per year, or about 6 per cent. of the total. From these figures the lower line in Figs. 1 and 2 is plotted and indicates the effect of fixed charges on the cost of power.

The remaining items of expense are what are generally termed operating charges, and are variable with load factor. These consist of (1) labour, oil and waste, supplies, water and repairs; (2) fuel.

The cost of labour varies, to a certain extent, with load factor, but a minimum number of men required to operate the plant is reached at about 40 per cent. load factor, below which this item remains constant. The cost of oil and waste, supplies, water and repairs varies almost directly with load factor, as the greater number of hours per day that the machinery remains in service the greater do these expenses become, and vice versa. The second line in Figs. 1 and 2 is for these charges reduced to the kilowatt-hour basis and is added to the fixed charges curve; the difference between the two curves, therefore, represents the cost of labour, oil and waste, supplies, water and repairs.

The cost of fuel, usually coal, per unit of power generated, varies with some power of the load factor less than one, depending upon the number and efficiency of units employed both in the engine and boiler rooms, also upon the cost per ton of coal, its heating value, and upon the ability of the firemen to get the best results. It is of the utmost importance to watch this item carefully, as greater economy can be secured in the cost of coal per kilowatt-hour than in any other item of expense. The calorific value of the coal should be tested from time to time and compared with the number of pounds used per kilowatt-hour.

The coal considered is assumed to contain 12,000 B. T. U.'s per pound, and two curves are plotted in Figs. 1 and 2 when the cost is $2 and $3 per ton, respectively, the results being added to the two previous curves plotted. These figures of fuel cost per kilowatt-hour are above the average usually obtained, and can only be secured by constant atten-

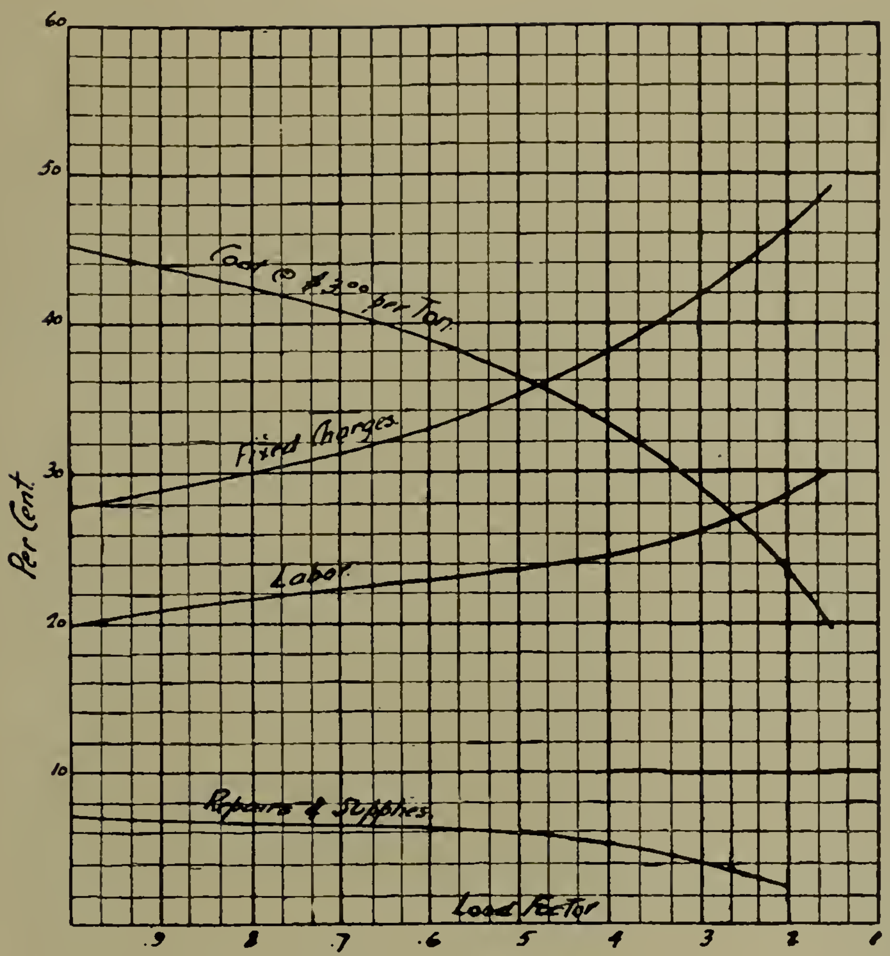


FIG. 3.—RATIO OF INDIVIDUAL ITEMS OF OPERATING EXPENSES TO TOTAL OPERATING EXPENSES FOR A 900-KW. CONDENSING STEAM PLANT WITH A 750-KW. PEAK

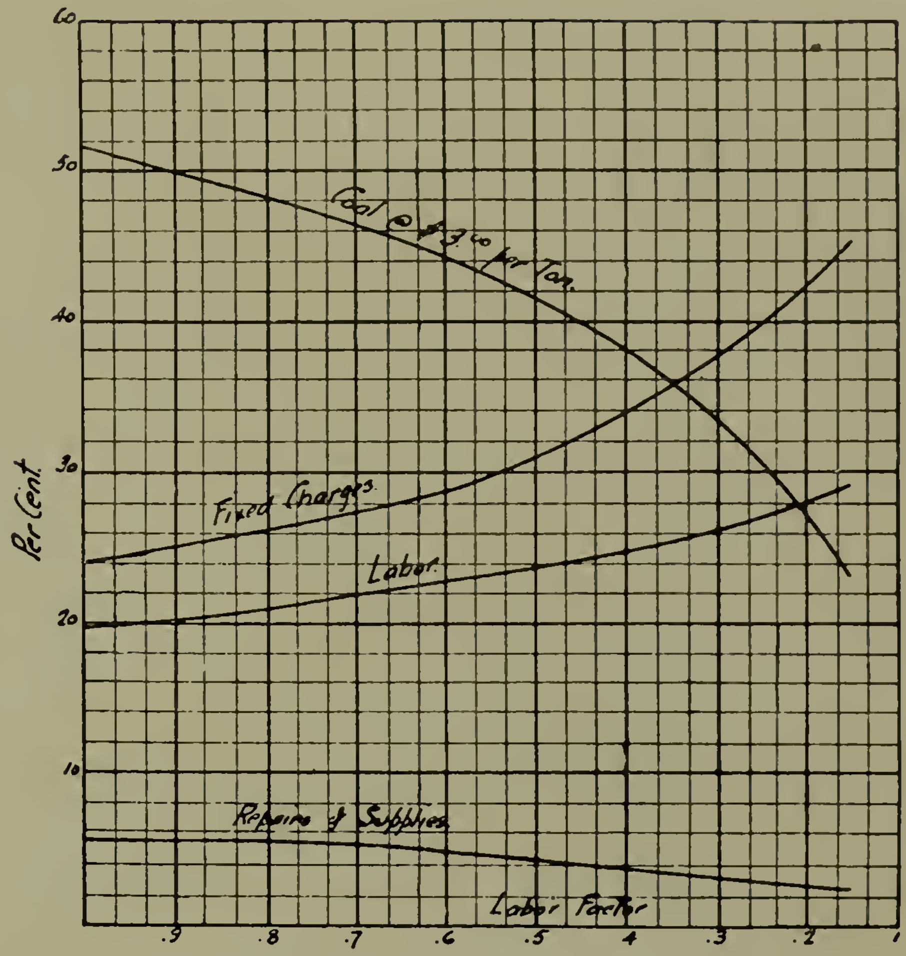


FIG. 4.—RATIO OF INDIVIDUAL ITEMS OF OPERATING EXPENSES TO TOTAL OPERATING EXPENSES FOR A 900-KW. NON-CONDENSING PLANT WITH A 750-KW. PEAK

tion in the boiler room; for instance, for 45 per cent. load factor in the first case 1 kilowatt-hour is generated from $13\frac{1}{2}$ pounds of coal from the pile.

The ratio of the individual items of expense to total operating expense is shown by Figs. 3 and 4 for the condensing and non-condensing plants, respectively, with coal at $3 per ton, delivered. It is interesting in connection with this to note the high percentage of fuel cost; in the average plant this percentage will be still higher than that shown, but this indicates how great a factor is the cost of fuel, particularly with high load factors. For low load factor the fuel is subordinated by the fixed charges, which are by far the heaviest item.

Having thus determined the cost of power for a plant with a peak of 750 KW., we shall consider briefly a larger plant and ascertain what extra economies may be secured. This plant we shall assume to have a peak load of 1500 KW. and a maximum capacity of 1800 KW., divided into three units of 600 KW. each. Stokers are used, but no economizers or coal handling apparatus; the boilers are in a single line parallel to the engine room, and coal is dumped from the car into a chute, whence it falls to the floor of the boiler room.

First cost of this plant at 100 per cent. load factor is $241,125, equivalent to $134 per KW. Fixed charges, using the same per cent. for interest, depreciation, taxes and insurance, as in the previous case, become $36,318.75 a year. Curves are plotted in Fig. 5 for fixed charges, labour, supplies and repairs, and fuel, the last-named being plotted for the two prices, $2 and $3 a ton, as before.

With all these curves before us, it might be well to make some deductions as to the advisability of further expenditures in the power plant in coal handling apparatus and

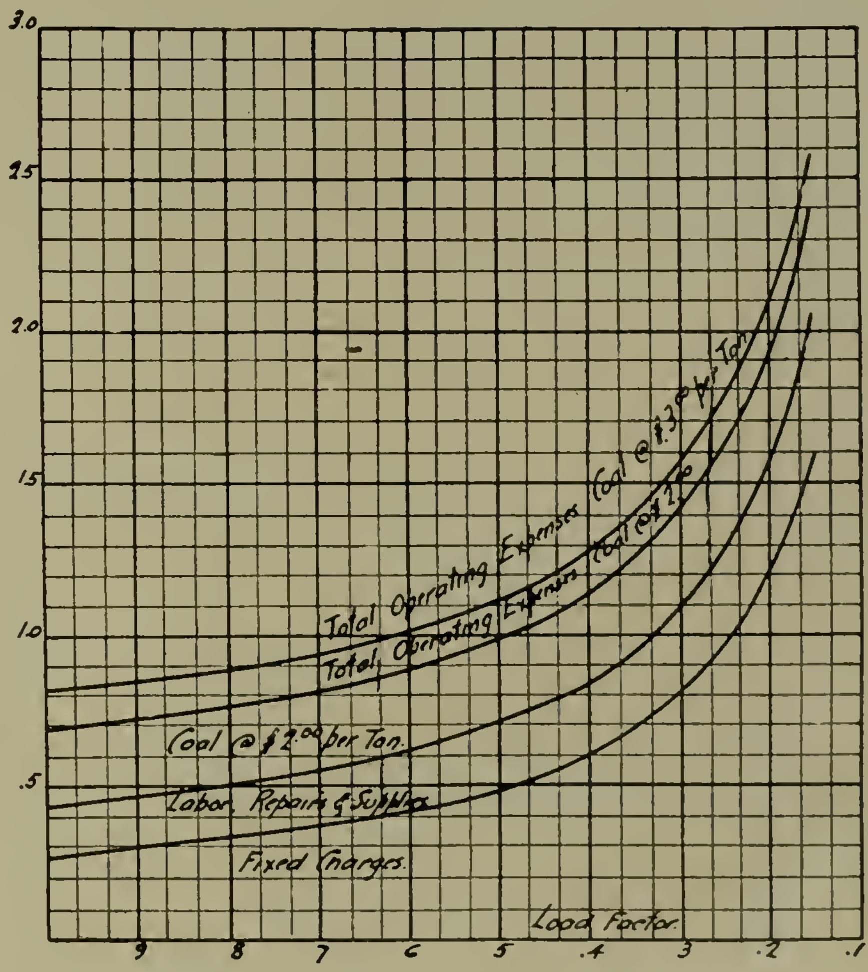


FIG. 5.—OPERATING EXPENSES OF AN 1800-KW. CONDENSING STEAM PLANT WITH A 1500-KW. PEAK

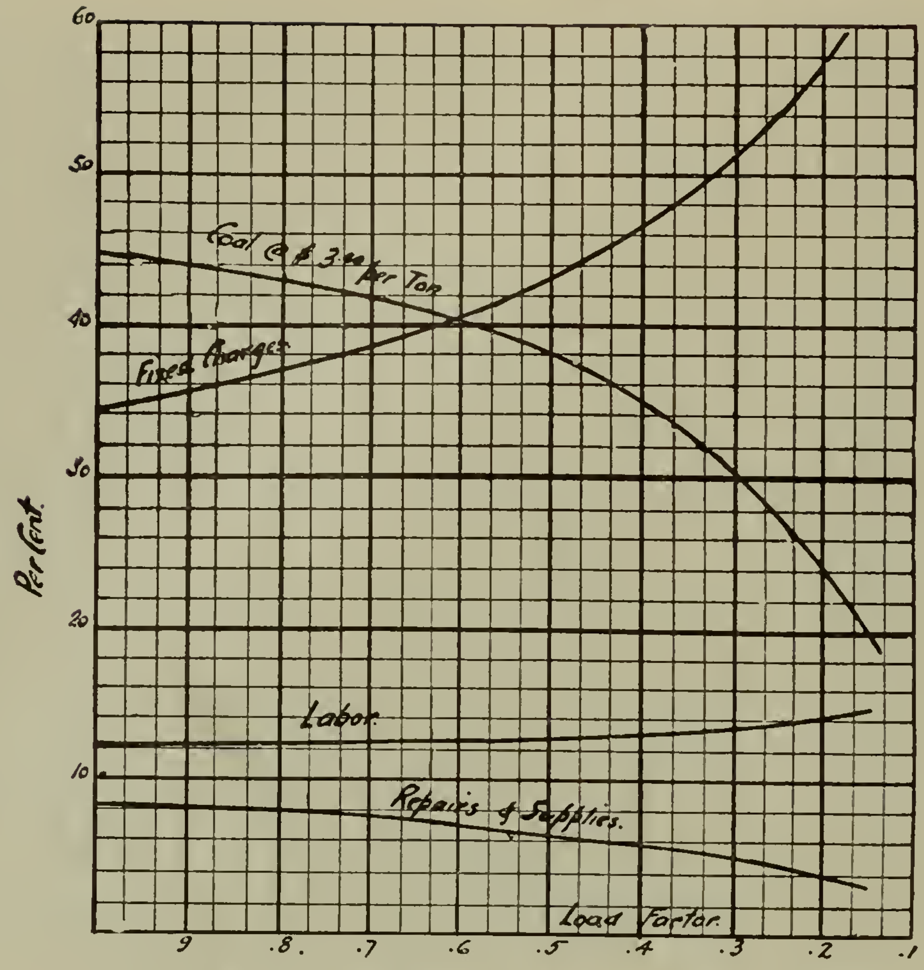


FIG. 6.—RATIO OF INDIVIDUAL ITEMS OF OPERATING EXPENSE TO TOTAL OPERATING EXPENSE OF AN 1800-KW. CONDENSING STEAM PLANT WITH A 1500-KW. PEAK

economizers, or, in general, any apparatus that tends to increase the economy.

The higher the load factor, the greater becomes the ratio of variable to fixed charges, and extra investment is advisable to secure the greatest economy possible. Extra investment in coal handling apparatus and economizers will reduce the cost of labour and fuel in greater proportion than fixed charges are increased; the economizers also provide greater boiler capacity and purer feed-water, reducing cost of repairs. On the contrary, when the load factor on a system is low, the fixed charges are the governing factor in the cost of power, and extra expenditures must be carefully considered, particularly so if fuel is cheap.

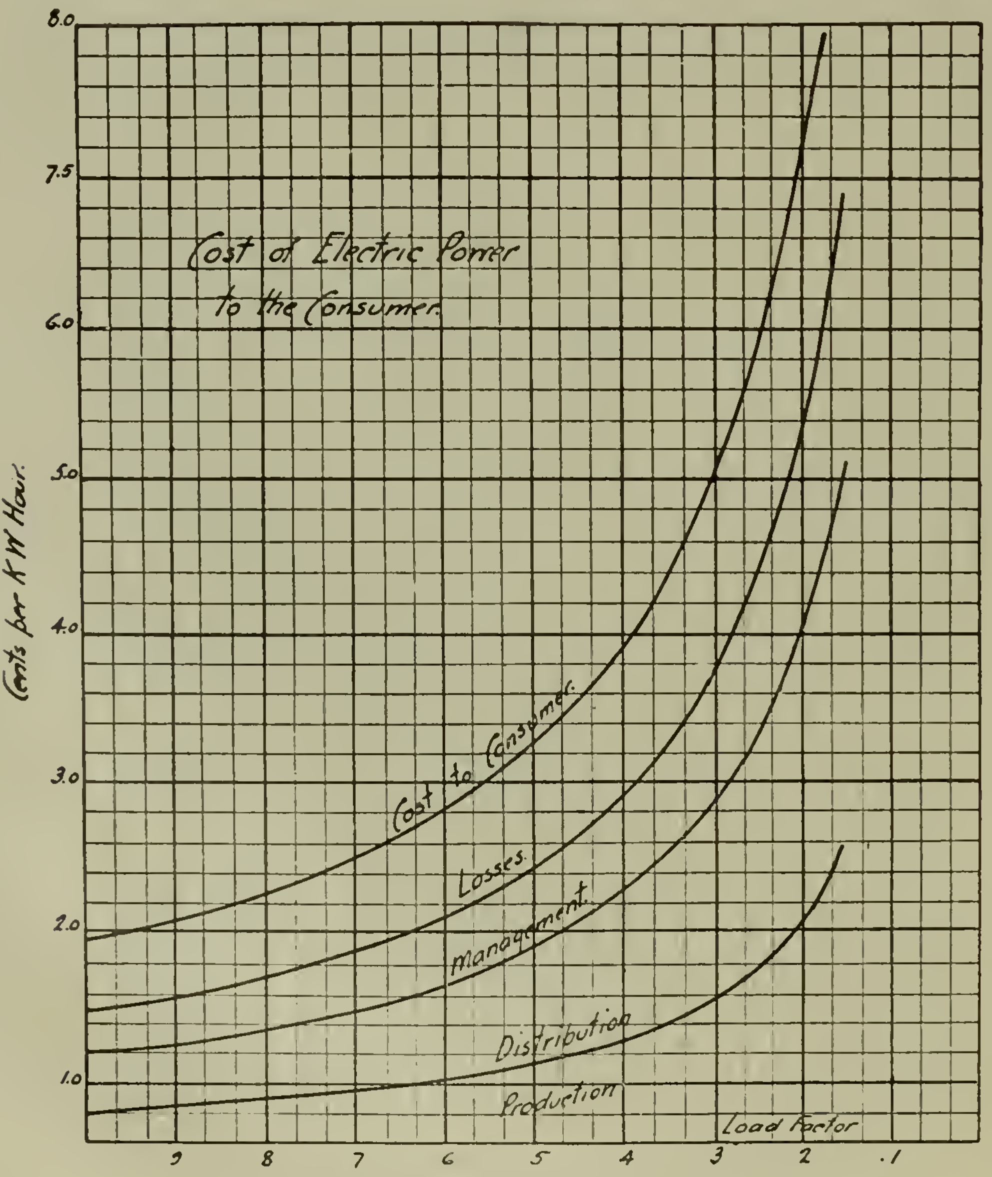


FIG. 7.—COST OF ELECTRIC POWER TO THE CONSUMER

Having thus discussed the effect of load factor on the cost of producing power, we shall next turn to the cost of management and distribution. While it is beyond the scope of this paper to fully consider these costs, yet it was thought advisable to indicate by a curve, including all the various costs approximately, how the load factor influences the cost to the consumer.

This is done very generally, as no two cases are alike; the cost of distribution is more variable with different systems than is the cost of power, depending on the conditions of distribution, conduit or pole-line construction, and the extent and density of the territory to be covered.

We shall allow that $50,000 a year covers all fixed charges, maintenance and attendance on the distributing network, and $35,000 a year for management, dividends on stock and miscellaneous expenses. For total losses 30 per cent. of the output is allowed; this is taken constant for all load factors, the actual losses from grounds are constant, hence percentage loss by grounds varies inversely as the load factor; losses from theft usually occur with customers having a short-hour load, and the greater the amount of such load connected, the greater this loss. A customer having a long-hour load runs a greater chance of detection than others. Hence the foregoing statement holds that the total percentage loss will be constant. Further, this lost power reduces the amount of sales, therefore affecting all the expenses included in cost to customer.

Fig. 7 shows a series of curves plotted for the 1800-KW. steam plant, the lower line representing cost of production; the second, cost of distribution; the third, cost of management; and the fourth, the effect of distribution losses on cost of power, the last-named being the final cost to the consumer.

Coal is expensive, and from the nature of things will increase in price, and it behooves us to investigate any methods of producing power which are more economical in the use of fuel than the steam engine. Naturally turning to the gas engine, we will next proceed to make a comparison between a steam plant and a gas plant generating producer gas for use in gas engines, and from such comparison deduce some general results.

As is well known, the gas engine has a very much higher thermal efficiency than the steam engine, which fact, together with the fewer number of auxilaries required, would naturally lead one to suppose that a greater economy could be secured in the production of powei

Difficulties, however, are encountered at the outset in the kind of fuel that may be used successfully in the gas producer. While the gas generated from anthracite coal is very successful in the operation of gas engines, the gas from bituminous coal contains tar, which, when carried through the valves into the cylinders of the engine, clogs the valves and carbonizes under the intense heat to which it is subjected in the cylinder, preventing successful operation. Some manufacturers claim to have succeeded in removing the tar or preventing its formation, but the burden of proof still rests with them.

The overload rating of the gas engine is different from the steam engine in the ratio of about 15 to 50 per cent. Hence in designing two plants, steam and gas, for equal overload capacities, it is necessary to use either gas engines of 25 to 35 per cent. higher normal rating, with consequent poorer economy at normal load, or add an extra engine and generator sufficient to take care of the extra overload capacity of the steam engine over the gas engine. For example, in designing a gas plant of 900 KW. capacity with a peak load of 750 KW., allowing the same reserve as in the steam plant considered previously, three engines of 530 B. H. P. each will be required with an aggregate normal B. H. P. of 1590 and maximum B. H. P. of 1830, as compared with three 450 I. H. P., equivalent to 410 B. H. P. engines aggregating 1230 normal B. H. P. and 1840 maximum B. H. P.; or three gas engines of 410 B. H. P. each and an additional engine of 360 B. H. P. aggregating 1830 B. H. P. on maximum load (from a practical standpoint, this additional engine would be made of the same capacity as the rest, the cost being the same). In the first case at normal load on the generators the engines are 30 per cent. under-loaded, with consequent poor efficiency; in the second case the first cost will be greater, due to the extra generator and increased size of building required.

Allowing the same reserve capacity in producers, and with three 530-B. H. P. gas engines direct connected to 300-KW. generators running at 100 revolutions per minute, the first cost becomes $167,650, equivalent to $186 per kilowatt.

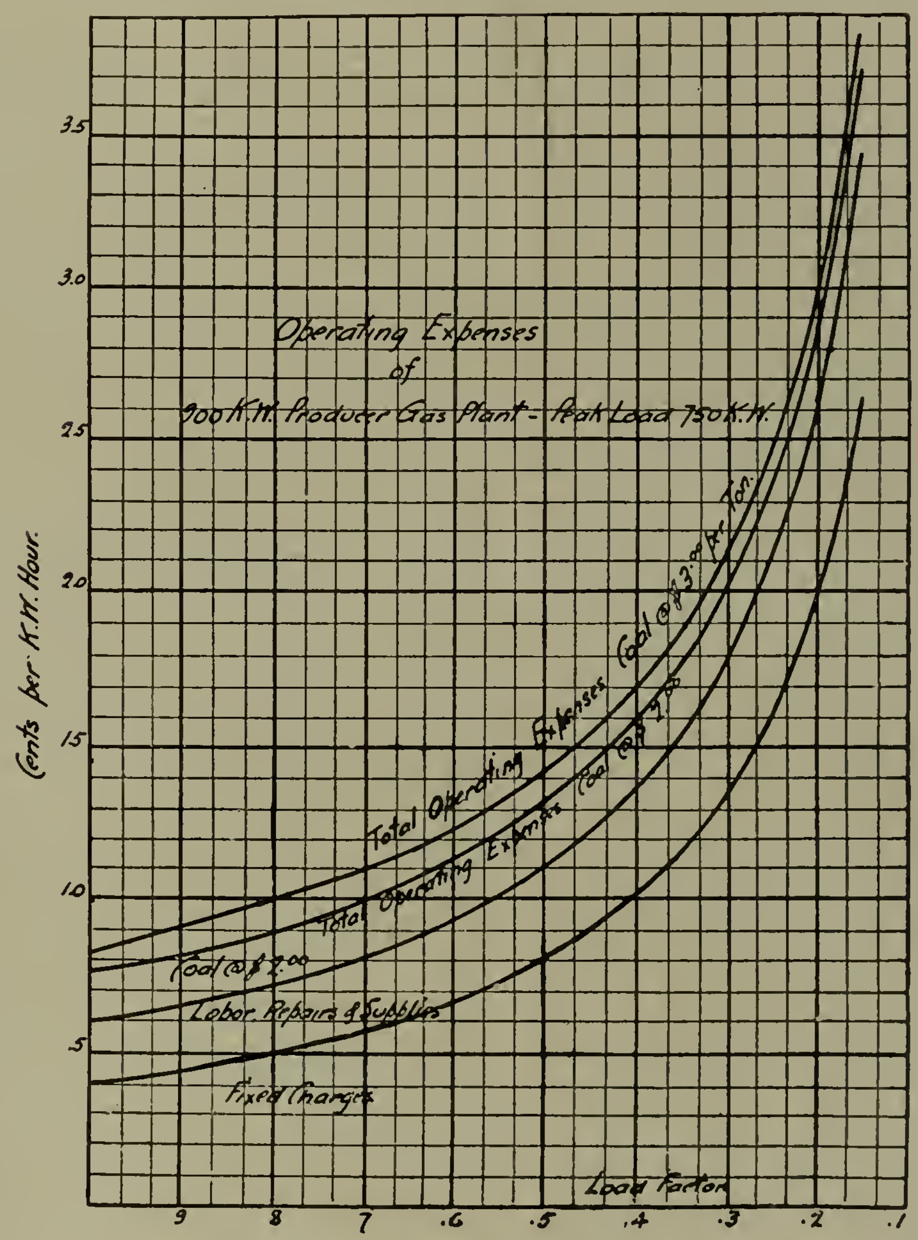


FIG. 8.—OPERATING EXPENSES OF A 900-KW. PRODUCER GAS POWER PLANT

FIXED CHARGES

Interest at 5 per cent. on $167,650........	$8,382.50
Depreciation on machinery, 10 per cent.	13,340.00
Depreciation on buildings, 3 per cent....	1,005.00
Taxes and insurance, 2 per cent..........	3,353.00
Total	$26,080.50

The storage capacity at 100 per cent. load factor is small, about 20,000 cubic feet, and is provided more for uniformity of gas than for storage. In case of accident to one producer, a second may be under way producing gas inside half an hour.

In a plant of this size where the number of producers actually required is not over two, with a third for reserve, it is more advisable to use the same number of producers for all load factors and a small amount of storage for uniformity of gas and sudden peaks.

In Fig. 8 are given curves for the cost of power with varying load factors for this 900-KW. gas plant. A comparison of Figs. 1, 2 and 8 shows a greater economy for the gas plant at the higher load factors, but poorer economy at low load factors, due to the influence of the heavy fixed charges. The higher the cost of coal, the greater is the economy of the gas over the steam plant at high load factors.

It must be remembered that the fuel economy in the case of the steam plants is taken considerably higher than the average and can only be secured by constant and careful attention to all the details around a power plant; in the gas plant, the fuel at 50 per cent. load factor is taken at 1.4 pounds of coal per B. H. P.-hour, which is somewhat higher than the manufacturers will guarantee. No matter how the fuel costs may vary from those given in these curves, they are relatively of far greater importance when the load factor is high than when it is low.

From the World's Technical Press

Water Rheostats for Alternating Current

WATER RHEOSTATS, as is well known, are frequently made use of to absorb large electrical energies, especially for dynamo and transformer tests. Fluid switches and current-regulators, consisting of sheet-iron electrodes in quadrant shape, lowered to adjustable depths into water or aqueous solutions of salt or soda, are applied in regular practice.

There is, however, a certain prejudice against the use of such apparatus for alternating currents. It has been maintained that the iron plates immersed in water acted like condensers, and would introduce a phase difference which might render the results of tests too favourable. Theoretically, this objection appears to be justified, and the question is, in how far the capacity effect should be allowed for in practice.

The problem has been investigated by K. Wallin in the Technical High School at Stockholm, who gives an account of his experiments in a recent issue of the "Elektrotechnische Zeitschrift." When experimenting with tap water or distilled water, a continuous flow of the water was maintained through the fluid cell, so that the temperature and the resistance of the device remained fairly constant.

In the case of solutions, the liquid did not circulate, but the distance between the electrodes was made adjustable. This distance was, as a rule, small, varying between 0.6 and 0.15 centimetre (0.23 and 0.19 inch). Measurements were made with voltmeters and amperemeters, and with oscillographs. In most cases the pressure and current curves did not show any phase difference, so that the use of fluid resistance would be unobjectionable in technical practice.

A phase lag was observed with solutions of soda at low pressures. Thus currents of 20 amperes and 1 or 1.5 volts gave no lag in soda solutions of 0.5 per cent., but solutions of 5, 10, and 15 per cent. showed increasing lag. As the pressure increased, the lag became less and less noticeable, however, and at pressures of 100 volts the lag became quite negligible.

Certain points appear yet to require further elucidation. The lag was greatest with strong soda solutions and small electrode distances; but the strongest soda solution applied, containing 3 kilogrammes of soda in 12 litres of water, showed neither any phase lag nor any peculiarity in the current curve.

Even when the one-plate electrode was replaced by a wire, no phase difference was observed with currents of 40 amperes at 30 volts. The solution was, of course, boiling in the neighbourhood of the wire, and explosions occurred which made the galvanometers very unsteady; yet the phases were not disturbed. It is not quite clear whether this strongest soda solution would, like the others, have given any phase difference at lower pressures, and the influence of pressure should have been fully investigated.

The Production of Sodium by Electrolysis

FOR many years, writes E. A. Ashcroft in "The Electrical Review," of London, attempts have been continually made to reduce metallic sodium directly from common salt by an electrolytic process. Up to the present time no successful method has come into use on an industrial scale, the old Castner process still holding the field. This method consists of the electrolysis of fused caustic soda, the total cost incurred being about 14½ cents for every pound of metal produced.

The caustic soda is an expensive item, as it can be used only in a pure state. Common salt, on the other hand, is easily obtainable even in a high state of purity, and is, as a consequence, an ideal source of sodium. The process here described consists of a combination of two methods.

The first stage consists of the formation of a sodium-lead alloy by the electrolysis of fused salt with a fused lead cathode. The second is the refining process, the lead-sodium alloy being made the anode, pure fused soda the electrolyte, and a copper or nickel sphere the cathode. The total cost of production is estimated at 5.9 cents per pound of metal

The plant in use consists of two cells joined together at the bottom, whereby the whole process is made continuous. Both are lined with suitable refractory material, and are heated externally. The current passes round the first cell to the anode suspended at the center, and sets up a strong magnetic field in the interior of the bath. The lines of force run perpendicularly, and the current in the fused lead cathode at the bottom of the cell cuts them at right angles, causing a circular motion in the fused metal. Thus, after the fusion of the introduced charge of salt the current deposits sodium in the stirred-up lead cathode, in which it is evenly distributed.

The main current then passes along the metal junction to the refining cell. Here the anode consists of the fused lead-sodium alloy prepared in the first cell. Fused caustic soda forms the electrolyte, and a hollow nickel sphere running through the bottom of the bath is made the cathode. The hollow part of the latter offers a cooling surface which solidifies the bath round the joints and forms an effectual seal.

Over the cathode a nickel funnel is suspended to catch the sodium as it rises, and protect it from the oxidizing influence of the air. This has an overflow at the top, down which the molten metal may run into a suitable non-oxidizing medium. This hood forms part of the anode system, to confine the whole of the metallic deposition to the hollow sphere, and thus avoid the formation of sub-oxides.

In this way sodium goes into solution at the anode, and is deposited at the cathode without changing the constitution of the bath. The metallic connection between the two cells consists of a composite pipe for the inflow and backflow of the molten alloy, which is kept in motion by the circulation set up in the cells. The working temperature in the first is about 700 degrees C., but it is somewhat lower in the regenerating bath. Thus the hot metal leaving the first cell heats up the colder impoverished alloy, and no clogging of the system is caused.

A Double-Trolley Overhead-Return System in Key West, Florida

In the city of Key West, Florida, the most southern city in the United States, the double-trolley overhead-return system was made necessary, says F. H. Porter in "The Electric Railway Review," because it had been found that there was no known form of bond which, after a few months' use, would show proper contact with the rails in which the bonds were placed, as the peculiar chemical elements of the soil would so eat away and destroy the steel at the point of contact that the bonding was absolutely worthless.

In order to obviate the loss of current from the enforced use of the ground for a return circuit, and the troubles which might follow ultimate electrolysis as the city grew, it became evident that the double-trolley overhead-return system was the only one which could be used with any economy. But here came the usual and well-known objections to the double-trolley overhead-return system as found in Cincinnati and elsewhere. There was the peculiar leakage at Key West through or over the ordinary forms of strain insulators, because of the deposit even during dry weather, and especially at night, of a saline coating covering the insulator and eating into any joint or crack. This gave a rapid deterioration of the insulator and especially a leakage of the current through this deposit carrying the current around the insulating material.

The question of proper insulation of the two trolley wires was solved by the use of two double-curve hangers, with a double-clevis giant strain insulator bolted between them, giving 18 inches space between the two trolley wires. At each of the outer ends of the double-curve hangers there was bolted a regular giant strain insulator with the usual ⅜-inch stranded steel suspension wire made up into the eye-end of the giant strain insulator. The other ends of the suspension wire were made up into eye bolts in the poles in the usual manner.

Hissing of the Iron Arc

In telling of work done in his laboratory with the iron arc, Prof. W. G. Cady, in a recent issue of "Nature," says that in experimenting H. D. Arnold found that at a certain critical potential difference an abrupt change took place in the conditions of an electric arc between iron electrodes. Subsequent investigation showed that the effect was closely analogous to the hissing point of the carbon arc.

If the iron arc be started with a large external resistance and maintained at such a length that the current is well below one ampere, it burns with little or no sound, and its appearance in the neighbourhood of the anode is very diffuse and ill-defined. As the external resistance is gradually decreased, the potential difference falls and the current rises, until a certain critical value, depending upon the length of the arc and the size of the electrodes, is reached. At this point a very small decrease in external resistance suffices to cause a sudden increase in current and drop in potential difference, precisely as with the carbon arc.

At the same time, the arc contracts, a bright spot appears on the anode, and a characteristic hissing sound begins. A further increase in the current is accompanied by a continued decrease in potential difference. The hissing stage begins at a different potential difference from that in the case of the carbon arc. If the experiment be carried out in the reverse order, starting with a large current, the discontinuity is encountered again, but not until the current has been diminished beyond the value that it had at the beginning of the hissing stage.

With the arcs of six millimetres (.234 inch) in length and more the current on the hissing stage can, with care, be decreased until it is smaller than the previous largest value on the quiet stage. Thus there are two possible values of potential difference for the same current and length of arc, one corresponding to the quiet, the other to the hissing stage.

With the iron arc there is no definite crater. Each electrode terminates in a viscous incandescent globule, apparently magnetic oxide of iron. When the arc is hissing strongly the discharge seems to take place from a small area on the surface of this globule. A large increase in diameter of the electrodes is accompanied by only a small increase in the value of the critical current. This varies between 0.8 ampere and 1.5 amperes, over a wide range of values of length of arc and thickness of electrodes.

With the arc burning on the quiet stage in the neighbourhood of the hissing point, hissing can be precipitated by shortening the arc. After the current has been increased somewhat beyond the hissing point the arc begins to rotate rapidly, producing a ring instead of a spot of light on the anode. This phenomenon is accompanied by a high-pitched whistle, which degenerates into a sputter and finally turns into a steady hiss as the current is further increased.

At the beginning of the whistling stage the arc has a curious tendency to jump back into the quiet stage. It is possible that slight irregularities in the electromotive force supply may serve to precipitate the change from one stage to the other, even though the current be not that at which the change normally takes place.

Atmospheric Dust and Electricity

In a recent issue of the "Physikalische Zeitschrift," G. C. Simpson deals with the question whether the dust floating in our atmosphere carries an electric charge. If the earth be negatively charged, as is commonly assumed, any dust stirred up from it should be so charged. A. Schuster has observed that the smoke from chimneys is negatively electrified.

A. Schmauss has ascertained that drops of water falling through ionized air becomes negatively charged, and as the air is, as a rule, ionized to a sufficient degree, we might also expect the dust to be negatively electrified. On the other hand, several experimenters have observed that dust seems to settle more on negatively charged, than on positively charged, wires; that would indicate that the dust itself was positively electrified.

Mr. Simpson himself, in his researches on the ionization of the atmosphere, had expressed the opinion that particles floating in the air are not electrically charged, and do not take up any charge from the air, but rather communicate any charge impressed upon them to the air. The question is of considerable importance with regard to the origin of atmospheric electricity. For if the dust be charged by the absorption of ions from the atmosphere, the dust particles falling upon the earth would electrify the earth.

In experiments made at the author's suggestion by Atkinson, at Manchester, the following arrangement was finally adopted:—Two brass plates, 8 centimetres by 4 centimetres, were mounted 1 centimetre apart, and charged to a potential difference of 5000 volts. The insides of the brass plates were covered with thin sheets of glass, so that the amount of dust settling on them could easily be ascertained.

After exposure to the Manchester air for thirty hours, both the plates were found coated with dust to about the same thickness. That would tend to indicate that the dust was either electrically neutral, or that both positive and negative charges occurred in about the same proportion. The amount of dust deposited in the open air and in closed rooms was also equal. The experiments, however, can hardly be regarded as conclusive.

Arc Lamp Carbon Ends

AN economical method of using up arc lamp carbon ends, instead of consigning them to the cinder tip or mortar mill, according to "The Electrical Review," of London, consists in cementing several ends together so as to form a single long carbon. The cementing is carried out by cutting the ends of the pieces so as to allow them to fit together, covering these ends with a paste made of water glass and powdered carbon, and then lightly pressing the pieces together.

Such made-up carbons burn, both with direct and alternating currents, just as well as new carbons, even at the junctions. Tests prove that the resistance is but little greater than that of new carbons, whilst as regards mechanical strength the made-up carbons, when subjected to a uniform stress, are found, if anything, more liable to break between joints than at the joints.

Experiments carried on at a railway lighting plant in the north of England showed that these made-up carbons were consumed without reducing the percentage of light rays which is attainable with perfect ones; neither was there any irregularity in feeding, a steady arc being maintained throughout. It should, however, be borne in mind that these remarks apply to single and twin carbon enclosed lamps only.

At some lighting plants it is customary, when lamp trimming, to renew the positive carbon and transfer the recovered piece, about 4 or 5 inches long, to the negative holder, because, as is well known, the carbon on the negative side is consumed at a much slower rate. Consequently not more than 2 inches of carbon per lamp is really wasted, and wherever such a practice is in operation it is a moot point which engineers must decide for themselves, whether carbon jointing is or is not desirable

A similar experiment was made in connection with the open type arc lamps on a direct-current 220-volt circuit. This pressure admits of four lamps being joined in series across the mains together with a slight resistance, the latter ensuring a normal current of 10 amperes passing through the lamps.

If a recording ammeter were inserted in the open arc 10-ampere circuit, a momentary rush of current amounting to about 28 amperes would be noticeable on the chart, but within two minutes the consumption would have fallen to the normal figure. Now this excessive current acted disastrously upon the made-up carbons, for as soon as the switch was closed the jointed ends became red hot, then incandescent, and immediately afterwards broke into as many parts as there were jointed sections.

Why such carbons proved a success with one class of lamps, and a failure with another type, may be accounted for by the excess of current at the moment of striking-up in the open arc, as compared with the enclosed arc circuit. The conclusion to be drawn from the foregoing tests supplemented by personal observation is this: A jointed carbon will safely carry a steady current of 16 amperes or thereabout, but will collapse when subjected to a greater amount.

Another useful purpose to which scrap carbon ends may be allocated is for lightning conductor work. Owing to the higher conductivity of carbon over that of coke, these broken pieces make an excellent bed for lightning conductors, and whenever the ground is being opened out for earth-plate repairs, this important fact should not be lost sight of. The relative values of coke and carbon for this class of work may be judged from the following:

A certain conductor was repaired some time ago, the earth plate being surrounded with coke, after which the usual test was made and balance obtained on the bridge galvanometer at 22 ohms. Shortly afterwards another conductor plate was laid in a similar sub-soil, but carbon ends were freely scattered thereabout; the resistance measured 1 ohm. A third conductor has since undergone renovation, but in addition to tipping two hand-cart loads of scrap carbon around the earth plate, a connection was made from the latter to a water main that was encountered during the process of excavation; the resistance offered was 0.4 ohm.

Reducing the Cost of Incandescent Lamps

IN the beginning of the career of the incandescent electric lamp, says "The Illuminating Engineer," about 75 cents worth of platinum was used in a single lamp, and the bulb was blown by hand from a piece of tubing. At the present time the platinum in a lamp costs about one-half cent, and the bulb, which is made in large quantities at the glass factories, costs about 2 cents. It may appear from this that the present selling price of such lamps—18 cents for the ordinary size—is unnecessarily high; but when it is considered that there are some fifty operations in the process of manufacture, nearly all of which require special skill and many of which involve refinements of manipulation which are nothing less than marvelous, this thought changes to one of wonder that the price can be made so low. Nevertheless, manufacturers are continually seeking to reduce the manufacturing cost; and a saving which would represent one or two-tenths of a cent on a lamp would be well worth considering.

An inventor in Toledo, Ohio, has constructed a machine for blowing the bulbs, which is said to reduce the cost to about one-quarter of the present amount. While the name of the inventor is not mentioned, it is very likely the same one who has perfected a bottle-blowing machine which is revolutionizing the whole blown-glass industry; so that there seems little doubt of his accomplishing similar results in the manufacture of lamp bulbs.

Platinum is more valuable, weight for weight, than gold, and the limited supply is controlled by the Russian government. Innumerable attempts have been made to find some substitute for this expensive metal in the manufacture of incandescent lamps; but while many devices have promised well, none have come into practical use. It is reported, however, that Maxim, the noted English inventor, has, after long study and research, succeeded in producing a metal which, when drawn into wire and platinum coated, answers the purpose of solid platinum in every particular. The metal has been tried on a commercial scale in England with apparently satisfactory results.

The Deterioration of Nickel Wire at High Temperatures Produced Electrically

THE results of some researches carried out in order to ascertain, if possible, the reason for a fundamental change in the mechanical properties of nickel wire used as the heating coil of an electrically heated porcelain tube furnace, were given by H. C. H. Carpenter in a paper read at the recent meeting of the British Association.

The wire contained 98.6 per cent. nickel, 1.22 per cent. iron, 0.16 per cent. manganese, and a trace of cobalt. Some dissolved gas or gases were also present. The diameter of the wire was one-sixteenth of an inch. The ultimate tensile stress was 35.2 tons per square inch, with a percentage of elongation of 34.4 on 3⅜ inches, and a percentage reduction of area of about 70. The resistivity at 0° C. was 9.2 microhms-cm.

In building the furnace the wire is wound round an unglazed porcelain tube (1¼ inches external diameter), which is enclosed in a wider one, the intervening space being filled with crushed quartz. The ends of the furnace consist of porcelain slabs which fit into the wider tube, and are bored so as just to allow the passage of the narrower tube.

In actual use the wire carries 20 amperes at 50 volts pressure, and a temperature of 1200-1300 degrees C. can be obtained in the tubes. With care the life of such a furnace is usually three or even more months; but sooner or later it breaks down. The wire is then usually found to be so brittle that it can be snapped between the fingers. Occasionally it is still tough, but has become perfectly fibrous.

These changes of mechanical properties are accompanied by structural changes which have been studied with the microscope. They are the result of the combined influence of heat and electricity, and are not produced by either of these agencies singly.

It appears that the changes are due mainly to two effects, viz., recrystalization and the penetration of gases, which are themselves the results of heat and electricity on the metal. The frequent association of brittleness with gross crystallization has long been known. But the evolution of dissolved or combined gas or gases from nickel and their mode of penetration through and eventual exit from it by means of cracks between the gross crystals are, it is thought, described here for the first time.

The Use of the Electric Arc in Clearing Away Steel Debris

THE clearing away of the mass of bent and twisted steel work left by the fire in San Francisco has been largely aided, says the "Journal of Electricity, Power and Gas," by the use of the electric arc in cutting up the steel.

It occurred to R. E. Frickey that the electric arc might be employed here to advantage, and he carried out at the University of California some experiments to determine the possibilities of this use of the arc. As a result of extensive experiments an electrode has been evolved which has proved successful. By means of this electrode a 15-inch beam was cut in two in twenty minutes. To make a corresponding cut with a hack saw would require several hours.

For the best and most economical results a current of about 250 amperes at from 90 to 100 volts is required. In starting, a resistance is employed, but this may be cut out after the arc is formed. One necessary condition for success is the satisfactory protection of the operator. Not only the eyes, but the face and hands, must be covered or they will be badly burned. An oilcloth hood having a rectangular opening in front of the eyes is employed, this opening being covered by a mask of oilcloth having a window of specially prepared glass when the arc is in operation. Gloves must be worn.

Since it is not practical to obtain 110 volts for the work in San Francisco, and as it was not advisable to use the 220-volt system, since the neutral is grounded in that city, a portable generating set consisting of a gasoline engine driving a dynamo was arranged. This consists of a 25-kw direct-current generator belted to a 40-H. P. single-cylinder gas engine mounted on a truck. The selection of the equipment was limited to a considerable extent by the apparatus available in the city.

Electrical Driving for Rolling Mills

ACCORDING to "The Electrical Review," of London, an electric reversing rolling train was recently put in operation at the iron and steel works of the Archduke Friedrich at Teschen, Austria. The installation is claimed to be the first of its kind and to have passed through its trials exceptionally well down to the present time.

The work, which was carried out by the Berlin General Electricity Company, has resulted in the receipt of new orders for similar rolling trains from a Hungarian works and a large German steel works, each order representing a value of from $125,000 to $250,000. This announcement apparently refers to the plant at Hildegarde Hutte, which was started in regular operation on July 27.

The application of electric driving to rolling-mill reversing trains is said to have brought about the complete centralization of the production of electrical energy at ironworks, as the reversing steam rolling train engine has hitherto been the sole engine which has maintained its position notwithstanding the varied applications of the electrical transmission of power.

The reversing train serves the purpose of rolling heavy ingots, about two tons in weight, into billets, double tees and rails, the available power being 10,000 H.P. The maximum speed of the train amounts to 120 revolutions per minute, and its acceleration from nil to this speed is normally attained in four seconds, although it can be reached in two seconds and a half in case of necessity.

No instance is said to have occurred of an ingot sticking fast, whereas this could not quite be avoided with steam power. The production of the mill is claimed to be 10 per cent. higher than when driven by steam engines.

In a note contributed to the sixth International Congress of Applied Chemistry, recently held at Rome, Mr. Gin gave the results of a measurement recently effected by him of the electrical resistance of molten iron and steel. He finds that the specific resistance of the molten metals at a temperature of between 1280 degrees and 1300 degrees C. is about 160 microhms, or about 94 times as great as that of pure solid copper at ordinary temperatures.

Electrical and Mechanical Progress

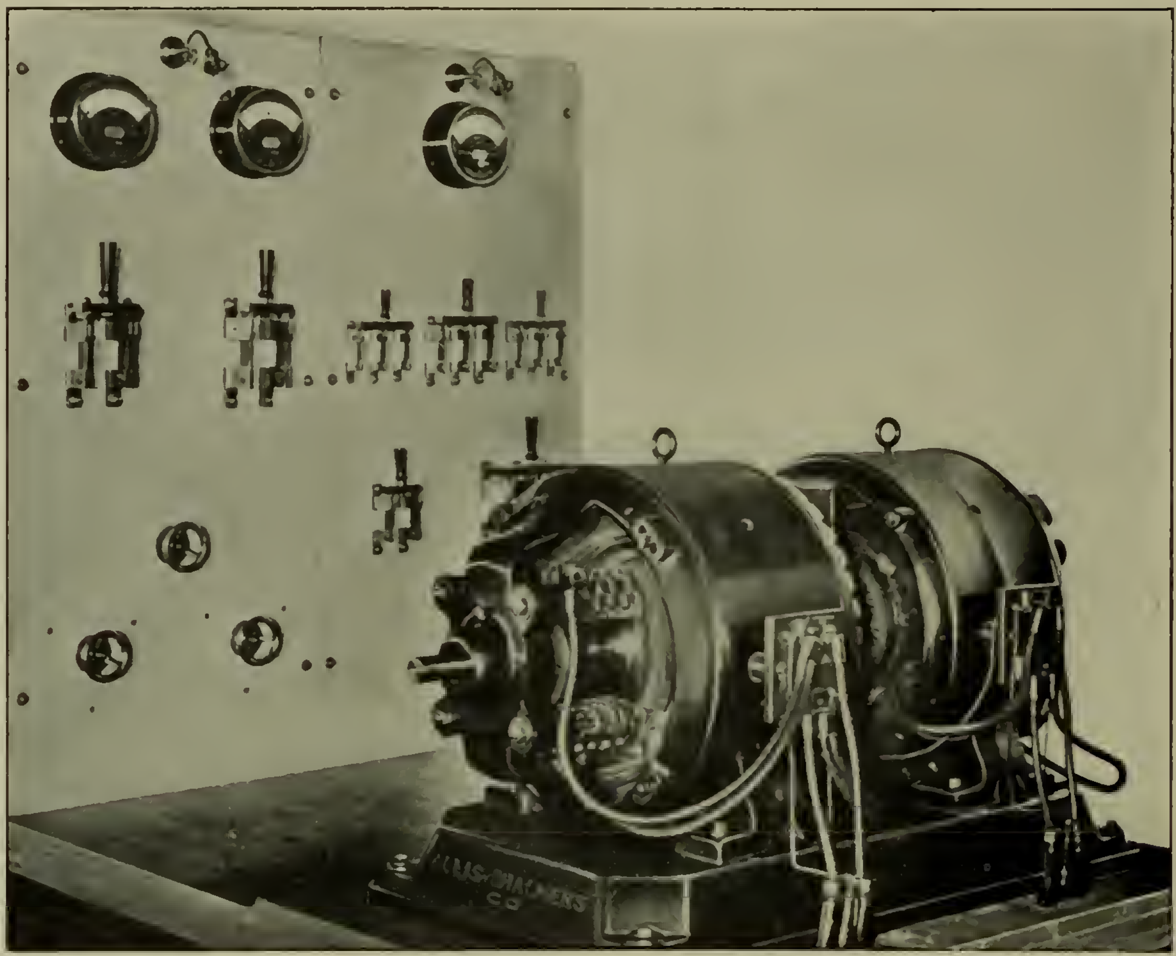
Multiple Voltage System of Motor Control in New England Cloth Printing Plants

THE eminently successful operation of several installations of multiple voltage systems of motor control, made by the Allis-Chalmers Company under the H. Ward Leonard patents, in cloth printing and finishing establishments in New England, has developed a wide field for the application of electric motors in this important industry.

Multiple voltage installations have been made in the following textile finishing works: The United States Finishing Company, Norwich, Conn.; the Algonquin Printing Company, Fall River, Mass.; the Glenlyon Dye Works, Phillipsdale, R. I., and the Arnold Print Works, North Adams, Mass.

The business of cloth printing is an extensive one, and in most cases is done under contract, the mill supplying the cloth as it comes from the looms to the finishing company, which does the printing, and puts it in proper condition for the market. The printing is done on one side of the cloth, and may be in black or some other single color, or may be in a variety of colors. Various kinds of cloth are printed, such as calico, dimity, lawn, silk, and the like.

The cloth printing machine consists of a large revolving cylinder, around which the cloth passes, and bearing against the cylinder with the cloth between are one or more, sometimes as many as ten, copper rolls, called printing rolls, upon which the design has been engraved, the number of rolls being dependent upon the number of colors used, a separate roll being used for each color. The roll, in revolving, takes up the color from a trough into which it dips and impresses the design upon the cloth. From the printing machine the cloth passes on through a drying room heated by steam to a high temperature, whence it emerges with the ink entirely dried, provided the speed of its passage through the drying room has been properly timed.



A 3-WIRE BALANCER BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, FOR A MULTI-VOLTAGE SYSTEM OF MOTOR CONTROL

Previous to the adoption of electric motor drive, the printing machines have each been driven by a twin-cylinder engine, direct coupled to the main driving shaft of the machine, the variation in speed being obtained by hand-throttling of the engine. The printing room was invariably a dirty, oily, damp place. The inefficiency of these engines, together with the large amount of condensation in the long steam pipes between boiler room and printing room, created a condition of power extravagance against which the electric motor drive has produced most favorable results in economy. The exhaust steam from the engines has in some cases been used for the heating of water, through indirect contact, for use in the dye houses, but the economy of the electric drive is so great that the live steam used in place of the exhaust from the engines is not a matter of much consideration.

The advantage of the multiple voltage system of electric drive of this class of work comes in its cleanliness, economy of power, saving in floor space, and the ability to obtain a line of speeds necessary for the varieties of work which may at times be put upon any printing machine. When using but one color, different speeds may be required according to the character and thickness of the cloth, and the design being printed upon the cloth, these conditions determining the maximum speed permissible with proper setting of the color.

With a number of colors, which usually means an intricate pattern, different speeds may be required to obtain the proper register as well as the setting of the colors. The printer finds the multiple-voltage system of particular advantage in "making ready," which usually consumes much time in getting the proper register and determining the proper pressure of the rolls to insure good setting of the ink. For this work very slow speeds and quick starting and stopping are a necessity. Once he has all adjustments made and has determined the proper speed for the work in hand, he lets it proceed, adjusting on the controller the notch at which he desires to run, so that if it is necessary to stop the machine it can be instantly set to work again at the same speed and without loss of time in finding the proper speed.

The usual method of equipping a printing machine is to install the motor on the floor below the printing room and belt up to a driving pulley on the main shaft of the machine. In one installation the motors are all located on a balcony above and to the rear of the row of printing machines. To save room, the most convenient method of locating the controller is to mount it on the ceiling of the floor below the printing room, the shaft of the controller being extended above and with the hand-wheel at a convenient height in front and to the right of the printing machine.

On account of the very slow speeds required at different times the four-wire multiple-voltage system is better adapted than the three-wire system. To obtain the slowest speeds, a few steps of armature resistance are used, and this has necessitated the development of a special type of controller. This controller will give eighteen speeds, the lowest of which are obtained through the use of armature resistance. Aside from the necessity for the slower speeds, the throwing of 60 volts on the motor armature for the first speed would cause a too sudden jump and result in tearing the cloth. This controller, with its eighteen speeds, properly meets the conditions of all ordinary work, but in connection with recent installation made for the Glenlyon Dye Works a new controller giving forty-one speeds was developed and is now in very satisfactory operation.

The power necessary to drive printing machines depends upon the number of colors for which they are built and in addition the pressure necessary to force the ink into the cloth being printed. Experience has demonstrated that for a machine built for three colors or less, an Allis-Chalmers 17½-H. P., 240-volt motor running at 750 revolutions per minute is well adapted, and for any greater number of colors a 30-H. P., 240-volt motor running at 1000 revolutions per minute.

A balancer having a capacity of 17½ K. W. in each machine has been found large enough to take care of the six 30-H. P. printing equipments already installed for the Glenlyon Dye Works, together with four other 12-H. P. equipments in the same plant, but driving another class of machinery.

The multiple-voltage system lends itself well to the equipment of other machinery in textile finishing works, such as soapers and tender frames, the latter being used to stretch and straighten the cloth. Soapers require a motor of approximately 18 H. P. at 900 revolutions per minute, and the 12-H. P. motor at 900 revolutions per minute is ample for tender frames, the motor in both cases being direct-coupled to the machine.

The multiple-voltage system has met with exceptional favor from the companies in which it has been installed. It is stated that the use of the Allis-Chalmers system has, in some cases, been known to effect a saving of over 50 per cent. in power.

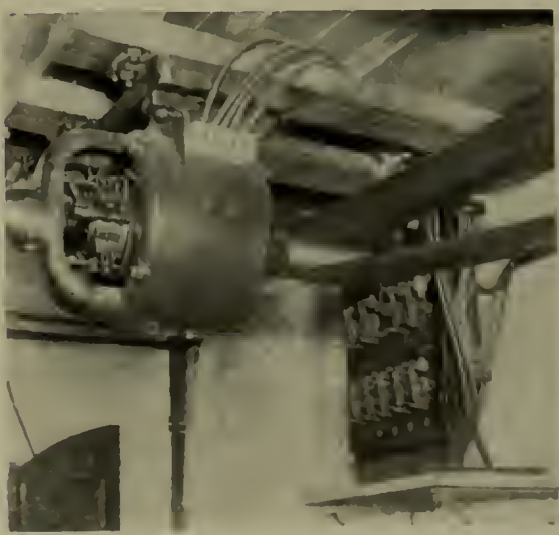
According to recent reports, an Italian syndicate has applied to the Minister of Public Works for a concession for a 120-mile electric road from Rome to Naples, which will be covered by express trains in one hour and forty minutes.

New Motor Starters and Elevator Controllers

NEW and interesting types of automatic motor starters and elevator controllers, manufactured by the New York Electric Controller Company, of New York, are shown in the annexed illustrations.

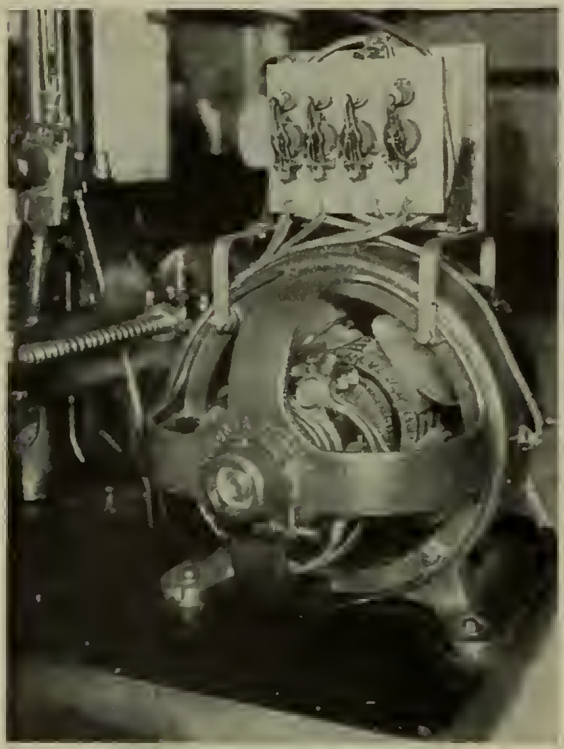
AN ELEVATOR CONTROLLER MANUFACTURED BY THE NEW YORK ELECTRIC CONTROLLER COMPANY, OF NEW YORK

The automatic controlling device for elevator use is designed to be used on any type of elevator operated by an electric motor, and can be used in conjunction with any motor, whether alternating or direct



AN ELEVATOR CONTROLLER ATTACHED TO A SIDE WALL current, series, compound or shunt types.

For elevator work, shunt motors over 5 H. P. are not recommended; when motors are wound with a series field in sections having suffi-



A MOTOR STARTER MOUNTED ON THE FIELD FRAME OF A MOTOR

cient ohmic resistance to cut the current down, the controller is furnished without any resistance, and contacts to suit. In all controllers above 10 H. P. the resistance is built from a special alloy of a rectangular section, and all joints are electrically welded together, no cast-iron grids being used in any form.

No solenoids are used; therefore, the controllers can be installed where the sliding core of a solenoid would soon become clogged up, preventing its operation. All the controllers are fitted with very powerful magnetic blowouts on the main line circuit-breakers, which are of the double-pole type.

The motor starters are for use where it is found desirable to start a direct-current motor automatically, or from a distance.

Where automatic control is required, in the large majority of instances, the starting and stopping of the motor is dependent on the service conditions. The most familiar are those in which the motor is pumping into an open tank, and it is required to stop the motor at the upper water level and start it when the water reaches the lower level. Similar conditions arise in closed tank and air compressor work, where it is desired to start the motor at a predetermined minimum pressure and stop it when the pressure has reached a predetermined maximum.

The motor starter is a modification of the elevator controller made without reversing contacts, and for operating motors is much more satisfactory than hand rheostats, as it is impossible for the resistance to be cut out other than in its proper order, and in the same manner as the elevator controller.

On large motors, in many cases, there will be a saving in wiring by the use of this apparatus, as both motor and starter can be placed near the work and operated from any part of the building by a small snap switch, with two small wires in place of heavy mains.

This apparatus can be put to many uses, such as operating pumps, organ blowing, grip hoists, ventilating fans, compressors, wood-working machines, and the like.

Electric Power in the Plant of the Springfield, Ohio, Metallic Casket Company

ELECTRICITY as a motive power for the operation of industrial plants has, by its obvious advantages, come into general use in all branches of manufacturing. The simplicity of electric motors, the ease with which they can be applied to almost any class of work, and the flexibility attending their use has created a large field for electric drive which is rapidly superseding the methods formerly used.

An illustration of this fact is found in the plant of the Springfield Metallic Casket Company, of Springfield, Ohio, where the rapidly increasing business created power demands that were considerably in excess of the steam engine equipment. Electric motors were therefore installed in preference to additional steam capacity. This company manufactures high-grade metallic caskets with self-locking covers that cannot be removed when once placed in position.

The electrical equipment consists of two Westinghouse motors of 50-H. P. capacity each, which are belted to line shafting, which in turn drives various machines. This is only one of the many instances where progressive companies have shown appreciation of the superiority of electric drive that led to its adoption.

Electrical Equipment for the Indiana Steel Company, at Gary, Indiana

AS already mentioned in these pages, an enormous plant is being constructed at Gary, Indiana, by the United States Steel Corporation for the manufacture of

ONE OF TWO 50-H. P. INDUCTION MOTORS INSTALLED BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, OF PITTSBURG, IN THE PLANT OF THE SPRINGFIELD, OHIO, METALLIC CASKET COMPANY steel. The new plant when completed will make use of substantially 5,000,000 tons of ore per year, and will produce annually nearly two and one-half million tons of steel. Along with the completion of the various buildings of the new plant an entirely new city is going up with parks, theaters, streets and water sewerage systems all planned.

Quite in keeping with the immensity of this project are the plans for the detailed equipment. Practically all the machinery in the steel plant will be driven electrically, the gases from the blast furnaces being, as far as possible, used for the generation of the necessary power. One of the first buildings to be equipped will be the rail mill, and the induction motors which will be used are not only of interest because of their size, but because of the special method of control. Moreover, this will be the first steel mill in this country to operate its rolls by induction motors.

Six General Electric three-phase induction motors, ranging in capacity from 2000 to 6000 H. P., will be used to drive the main rolls. These motors are reversible and are specially controlled. Due to the heavy overloads to which these machines are necessarily subjected, each motor is provided with a heavy fly-wheel which, with the system of control, stores up energy when running normally and returns it to the rolls when subjected to a heavy overload.

In addition to the heavy fly-wheels, each induction motor has an overload capacity of 50 per cent. for one hour. Thus, three of the motors having a normal rating of 6000 H. P. can each deliver 9000 H. P. for one hour when called upon to do so. Mechanically these motors are of unusually sturdy construction, being built heavy and rugged to withstand the shocks to which they will be necessarily subjected. At the same time the construction is as simple as is consistent with reliability. The heavy bearings and general massive appearance of these motors is quite in keeping with the powerful rolls which they drive.

The method of controlling these motors was especially designed by the General Electric Company for this service, and is very interesting. A master controller is used from which the main line oil switch can be opened or closed, the reversing switch thrown in either position, or the resistance cut in and out of the rotor circuit in successive steps by means of electrically operated switches or contractors. The main line switch is a triple-pole, single-throw, electrically operated oil switch and the current passing through this is led through the reversing switch of the double-pole, double-throw, electrically operated oil type.

Special precautions have been taken to insure the automatic protection of the control system. It is impossible to operate the reversing switch unless the main line switch has been previously opened, and if the main line switch has been opened by the overload trip, it cannot be closed without first bringing the controller to the off position.

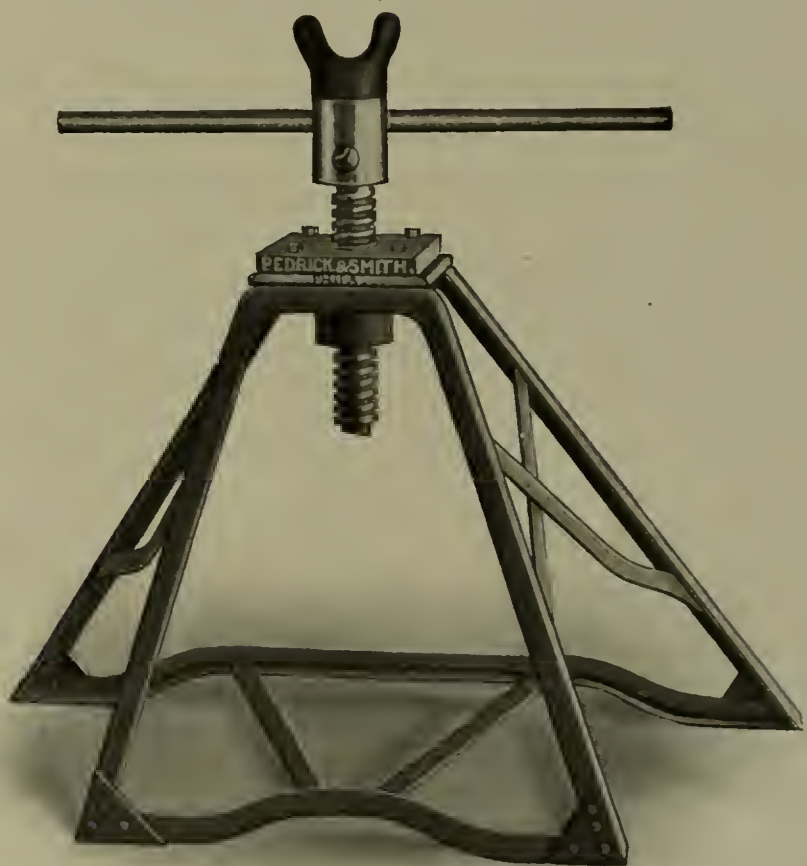
As has been stated, a special arrangement is used to assist the fly-wheel in restoring energy to the motor. So-called "slip relays" are provided in which the actuating coil carries the current of the motor. Whenever the motors are subjected to overloads, the slip relays operate, cutting a small portion of the resistance into each phase of the rotor circuit, causing the motor to slow down gradually, and the fly wheel will give up a portion of its energy. When the load is taken off the motor, the reverse operation takes place and the motor speeds up, returning the energy to the fly-wheel.

A Capstan Cable Jack

THE fact that the devices on the market for handling the large cable drums in connection with laying underground cable are heavy, clumsy and unsatisfactory in many ways, and also that the laying of underground cable increases enormously each year, has led to the invention of a screw capstan cable jack by Pedrick & Smith, of Germantown, Philadelphia.

The need of such an appliance has been severely felt in the field of its intended use. This simple device gives the user all that he desires. It is light, weighing but 60 pounds, and is readily portable, yet is strong, handling the heaviest cable drums in the most rigid manner. When the drum is revolving, not the least vibration is noticed.

Steel angles, strongly braced, form the stand. In the construction of the stand strength is combined with lightness. The jacks are used in pairs, one supporting each side of the drum, which revolves on an axle. The illustration shows a jack ready for the drum. The side facing the reader is that which stands next to the drum, and will be hereafter referred to as the inner support, the opposite side being referred to as the outer support.



A SCREW CAPSTAN CABLE JACK BUILT BY PEDRICK & SMITH, GERMANTOWN, PHILADELPHIA

The inner support is constructed to take up as little room as possible and to allow the drum to revolve as near to the jacks as possible. Toward the drum it has very little slant, consisting of just 1½ inches from the perpendicular. This feature adds strength, as it allows the drum to revolve close to the jacks. The spread of the inner support just covers 12 inches, which does not interfere at all with the man operating the drum. This feature also permits placing the drum nearly over the manhole or aperture in which the cable is being laid.

In the outer support, the slant from the drum is $5\frac{1}{2}$ inches from the perpendicular. The spread of the outer support is 36 inches. Toppling in any direction is impossible.

The drum revolves as firmly on these jacks, it is claimed, as if it were relying on solid masonry for its support. There is no perceptible vibration or tilting, as the weight is evenly distributed. The screw threads are heavy, and of such a pitch as to raise the drum rapidly with little effort.

Personal

Louis B. Marks has been retained as consulting engineer in illumination for the library building now in course of construction in New York, the funds for which were donated by Andrew Carnegie. These buildings exceed fifty in number. The selection of Mr. Marks by the advisory board of architects, Carrere & Hastings, McKim, Mead & White, and Babb, Cook & Willard, is not only a flattering acknowledgement of his ability, but also an indication that the field of the illuminating engineer is becoming a recognized one.

H. K. Payne, former manager of the Houston, Tex., Electric Company, and who for the past several months has been in charge of the purchasing department of the Stone-Webster syndicate, will now make Houston his permanent home, and will be connected with Fred A. Jones, consulting engineer, and who has a number of extensive engineering enterprises on foot. Mr. Payne will have charge of the affairs of the Houston office.

Horatio A. Foster, the well-known consulting electrical and mechanical engineer, is now associated with Lewis B. Stillwell, and has removed his office from the Bullitt Building, in Philadelphia, to Baltimore, where he is established as resident engineer in charge of the office recently opened by Mr. Stillwell in the Continental Building. Mr. Foster, as is well known, is the author of "Foster's Hand-Book of Electrical Engineering," which is by far the most complete and valuable work of the kind thus far issued; he has also published a very useful book relative to central station acounting, of which subject he has made a special study. While Mr. Foster's engineering ability and experience cover a wide range, he is particularly expert in the work of valuation of electric properties, having for many years been the highly successful and trusted adviser of some of the most important banking houses in Philadelphia and elsewhere. Mr. Stillwell has closed a contract with the United Railways & Electric Company, under which he has assumed responsibility for electrical and mechanical work in reconstruction and new construction, and also of operation of the power plants of the company. He expects to do in Baltimore what he did in Niagara Falls several years ago, viz., complete the construction of the power plant and organize and train an operating force for its proper operation. This work is a specialty of Mr. Stillwell's, and he regards the organization and training of a competent operating force as a very essential part of the work in connection with the construction of power plants. In Baltimore he has undertaken to accomplish this in one year.

Thomas M. Keeley, formerly superintendent of the Michigan United Railways, has been appointed general manager of the Michigan Heat & Power Company, with headquarters at Lansing, Mich.

C. O. Baker, formerly of the Telluride Power Company, of Utah, has been appointed superintendent of the Telluride Electric Light & Power Company, of Telluride, Col.

It is announced by Sanderson & Porter, of New York, that Richard S. Buck, C. E., consulting engineer of the Department of Bridges of the city of New York, has been admitted as a member of the firm. His connection with the Department of Bridges will continue for the present.

J. St. John, general bookkeeper of the Milwaukee Gas Light Company, has accepted the position of secretary to the Muskegon Light & Traction Company, of Muskegon, Mich.

Earl McDonald has accepted a position with the Shasta Power Company, and will proceed to Redding, Cal., where he expects to be engaged during the next year in the construction of a large hydro-electric plant.

F. C. Finkle has resigned his position as chief engineer of the Edison Electric Company, of Los Angeles, the resignation to take effect January 1. Mr. Finkle plans to devote his time to consulting engineering work and will have an office in Los Angeles. He will be retained as consulting engineer by the Edison Electric Company. He has already been retained as a consulting engineer by Curtis & Hine, of Colorado Springs, in connection with some of their important Colorado projects. Mr. Finkle has been chief engineer for the Edison Electric Company for a number of years and has been largely instrumental in the design and construction of its seven hydro-electric plants in Southern California.

Prof. Dugald C. Jackson, of the University of Wisconsin, has been appointed head of the electrical engineering department of the Massachusetts Institute of Technology. This vacancy, which has been held temporarily by Prof. Clifford, was caused by the resignation of Prof. Louis Duncan two years ago. Prof. Jackson was born in Kennet Square, Pa., in 1865. In 1885 he graduated from the Pennsylvania State College and went to Cornell for a two years' graduate course in electrical engineering. For two years he was vice-president of the Western Engineering Company, of Lincoln, Neb., and then became affiliated with the Edison interests as assistant chief engineer of the Sprague Electric Railway and Motor Company. Later he became chief engineer of the central district of the Edison General Electric Company. During this period he designed, built and operated many of the largest electric railway and lighting plants, and is now advising engineer for several large corporations. He was a member of the international jury of the World's Columbian Exposition in 1893, and of the Association of Scientists at the Pan-American Exposition in 1901, and is the author of many well-known books and papers.

C. W. Ricker, formerly engineer of power houses, sub-stations and electrical distribution for the Interborough Rapid Transit Company, of New York, has become associated with the Cleveland Construction Company, of Cleveland, Ohio, as electrical engineer in charge of the electrical end of the work on several lines which this company is now building in the Central West. Mr. Ricker will have his headquarters in the Schofield Building, Cleveland, Ohio.

C. F. Baker has been engaged by L. B. Stillwell as superintendent of power and construction in connection with the engineering and operating contract which Mr. Stillwell has recently executed with the United Railways & Electric Company, of Baltimore. Mr. Baker has filled the office of president of the American Railway, Mechanical & Electrical Association, and has also taken a prominent part in the New England Railroad Club and of the New England Street Railway Club. For many years he was with the West End Street Railway Company, of Boston, and the Boston Elevated Railway Company, in charge of the construction and operation of their power plants and rolling stock.

Frank H. Taylor, for the past six years vice-president of the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., and previously the manager for seven years of the Yale & Towne Manufacturing Company's branch office in Philadelphia, has re-entered the latter company's service at the invitation of the directors, and with the expectation that, after the necessary action has been taken at the next meeting of the stockholders, he will become a director and vice president.

Samuel C. Shaffner, formerly engineer and general manager of the Illuminating Company, Mobile, Ala., and G. R. Hunt, formerly manager and engineer of the San Diego (Cal.) Consolidated Gas & Electric Company, have joined the engineering staff of H. M. Byllesby & Company, and will be located at the Chicago office. O. A. Farrar, formerly with the Allis-Chalmers Company, is now in charge of the construction of a large electric lighting plant which H. M. Byllesby & Co. is building at Mobile, Ala.

Paul Lüpke has accepted President Williams' invitation to serve again as editor of the "Question Box," of the National Electric Light Association, and has already begun the preliminary work. Mr. Lüpke's work in this department of the Atlantic City programme was most excellent, especially when it is considered that he was asked to undertake the work but a short time before the convention. With the experience gained, and opportunity now given for more leisurely and careful editing, there is every reason to believe that the 1907 "Question Box" will be far in advance of its predecessors.

Obituary

Philip F. Kobbe, vice-president and treasurer of the Westinghouse Electric & Manufacturing Company, died at his country place in Stockbridge on Sept. 21. He had been ill for several weeks. Mr. Kobbe was born in New York on Oct. 24, 1842, and was educated in Germany. He served in the Civil War as a member of the Seventh Regiment. He was prominently associated with the old United States Lighting Company when it was absorbed, in 1890, by the Westinghouse Company, and was then elected vice-president and treasurer of the corporation. He was also identified with the British and French Westinghouse companies. Mr. Kobbe was a member of the Calumet and Richmond County Clubs and the Society of the Colonial Wars. A wife and five children survive him.

B. H. Warren, formerly vice-president of the Westinghouse Electric & Manufacturing Company, and later president of the Allis-Chalmers Company, died in New York on October 20. Interment was at Quincy, Mass., on October 25. Mr. Warren graduated from the United States Naval Academy in 1874, and after four years of active service was associated with the Hancock Inspirator Company, of Boston, as mechanical engineer. After a number of years with the Yale & Towne Manufacturing Company, of Stamford, Conn., and the Pratt & Whitney Company, of Hartford, Conn, he was invited by Mr. George Westinghouse to Pittsburg. After six years there he became president of the Allis-Chalmers Company. At the time of his death Mr. Warren was engaged in independent consulting engineering work.

Trade News

The Novelty Incandescent Lamp Company, of St. Marys, Pa., have transferred their office to their factory at Emporium, Pa.

The Buckeye Electric Company, of Cleveland, Ohio, has opened an office in Dallas, Tex. The office is in charge of H. E. Wells, and is located at 216 Commerce street.

The Connally-McIlheran Electrical Engineering Company, of Chattanooga, Tenn., was recently incorporated with a capital stock of $10,000. This company comes into the field with a strong force of engineers and proposes to do consulting and constructing engineering, sell the leading electrical machinery and supplies of all kinds and do all kinds of repair work. They will give special attention to industrial plans, and years of practical experience in this class of work especially fits them for it. The engineers identified with this company consist of the following:—W. B. Connally, formerly electrical engineer of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio; W. C. McIlheran, formerly electrical engineer for the Decatur Car Wheel & Manufacturing Company, of Birmingham, Ala., also recently with the Tennessee Coal, Iron & Railroad Company; W. C. McAfee, electrical engineer for the Atlanta Steel Hoop Company, of Atlanta, Ga.; H. A. Clark, electrical engineer for the United States Cast Iron Pipe & Foundry Company, Chattanooga, Tenn., also formerly electrical expert for the Gregory Electric Company, of Chicago. The last two gentlemen will not be actively identified with the company for the present.

The Rust Boiler Company, of Pittsburg, Pa., has secured the order for the boilers for the United States Steel Corporation's new plant at Gary, Ind., the order being for sixteen 400-H. P. Rust water-tube boilers.

Engineering and construction work on which Sanderson & Porter, of New York, are now engaged includes the Stanislaus River hydro-electric development in California, and that for the Inland Empire Railway Company, at Spokane, Wash., aggregating some 50,000 horse-power; extensive additions to the street railway and electric light properties of the New Orleans Railway & Light Company, and those of the Mahoning & Shenango Railway & Light Company, of Youngstown, Ohio, and New Castle, Pa.; and the power house equipment and transmission system of the McCall Ferry Power Company, on the Susquehanna River. The firm of Sanderson & Porter was established about ten years ago, and now consists of Messrs. Edwin N. Sanderson, H. Hobart Porter, Francis Blossom, Richmond Talbot and Richard S. Buck.

What is said to constitute the largest individual order ever placed for tube mills for the grinding of cement clinker is one recently placed by the United States Steel Corporation. This order calls for forty-seven tube mills, 5 feet in diameter by 22 feet in length. Twenty of these are to be installed in the plant of the Carnegie Steel Company, at Homestead, Pa., and twenty-seven are for an extension to the immense modern cement plant of the Illinois Steel Company, at Buffington, Ind. This entire order was awarded to the Power & Mining Machinery Company, of Cudahy, Wis. In addition to the order for the forty-seven tube mills above mentioned, the company has also booked an order for fourteen tube mills, 5 feet by 22 feet, and a complete crushing plant, consisting of large and small crushers and rotary screens, for the new plant of the Sandusky Portland Cement Company, at Dixon, Ill.

The Electric Controller & Supply Company, Cleveland, Ohio, announces the opening of a Chicago office in the Merchants' Loan & Trust Building, 135 Adams street, Chicago, Ill., with W. M. Connelly in charge. Mr. Connelly was connected with the electrical department of the Homestead Works of the Carnegie Steel Company for five years, and resigned his position there to become electrical engineer of the Ensley plant of the Tennessee Coal, Iron & Railroad Company, at Birmingham, Ala., which position he held for three years and resigned to enter central station work at Birmingham, Ala., and at Houston, Tex., where he organized and had charge of the sales department. Mr. Connelly enters upon his new duties fully equipped to take care of the interests of the Electric Controller & Supply Company in the Chicago district.

The Hooven, Owens, Rentschler Company, of Hamilton, Ohio, have licensed the Felten-Guilleaume, Lahmeyer Werke, of Frankfort-on-Main, Germany, to build the "Hamilton-Holzwarth" turbine throughout Germany. The Felten-Guilleaume, Lahmeyer Werke is one of the largest electrical concerns of Germany, with a capital of $20,000,000, and occupy the same position abroad as the General Electric and the Westinghouse companies do in America. They manufacture both water and steam turbines, wire cables, generators, motors, and all classes of electrical machinery, having recently bought the control of the Escher, Wyss Company, of Zurich, Switzerland, thus controlling the Zoelly steam turbine syndicate of Germany.

The W. R. Garton Company, of Chicago, report that the month of August was the heaviest month they have ever experienced in their business since the organization of the company, it being 50 per cent. ahead of any month previous. The month of October, thus far, is 30 per cent. heavier than September. This company has been organized nearly seven years, and every year has shown an increase in the business of at least 50 per cent., with the exception of the last two years, which have shown an increase each year of 66⅔ and 70 per cent., respectively, over any previous year, and, at the present rate of increase, the year 1906 will be more than 100 per cent. over any of the previous years.

New Catalogues

A neat folder, accompanied by samples of red rope paper, is being sent out by M. W. Dunton & Co., of Providence, R. I. The samples of paper show the sizes carried in stock for insulating purposes. A large stock in different widths and thicknesses is carried constantly.

Lava for mechanical and electrical purposes is dealt with in a pamphlet recently issued by the American Lava Company, of Chattanooga, Tenn. This material is not of volcanic origin, but is the mineral talc, which is machined in its natural condition and then baked until extremely hard. This "lava" finds a wide field of usefulness as an insulating material in electrical work. It is also claimed to be acid-proof and superior to porcelain and glass in heat-resisting qualities and in strength.

Railway motors and controllers built by the Allis-Chalmers Company, of Milwaukee, are illustrated and described in a bulletin recently issued. The motors are of the direct-current type, for 500 and 650-volt circuits. Another bulletin is devoted to polyphase induction motors. Both wound-rotor and squirrel-cage-rotor types are illustrated.

A very complete catalogue of specialties was recently sent out by the General Electric Company, of Schenectady, N. Y. The list includes a wide variety, from lamp sockets to cabinet panels. A series of bulletins also sent out by the company deal with wrought copper cable terminals, arc headlight parts, interpole motors, carrier bus arc panels, luminous arc lamp parts, polyphase induction motors, railway motors and feeder regulators. Core-type transformers are also illustrated and described in a recent pamphlet.

An attractive pamphlet sent out recently by the Ball Engine Company, of Erie, Pa., bears the cover title, "Twenty-five Years Young." The company was established in 1881. The pamphlet recites the facts established in the success of the company up to the present, and illustrates the following types of engines: Side-crank, single-cylinder; tandem-compound, side crank; cross-compound, side crank; horizontal single-cylinder Corliss; horizontal cross-compound Corliss; and vertical cross-compound Corliss.

Holding Power of Railroad Spikes

THE forest service of the United States Department of Agriculture has completed a series of tests to determine the holding power of different forms of railroad spikes. The tests were made on ordinary commercial ties of loblolly pine, oak, chestnut and other woods.

The spikes were of four kinds:—Common driven spikes; a driven spike which is about the same form as a common spike with a lengthwise channel on the side away from the rail; screw spikes of the American type; and screw spikes similar to those in use on the European railways.

The common spikes were driven to a depth of 5 inches and the screw spikes were inserted after a hole of the same diameter as the spike at the base of the thread had been bored. The average force required to pull the common spikes varied from 7000 pounds in white oak to 3600 pounds in loblolly pine and 3000 pounds in chestnut. The channel spike showed a slightly larger holding power.

The two forms of screw spikes were about equal in their holding power, which ranged from 13,000 pounds in white oak to 9400 pounds in chestnut and 7700 pounds in loblolly pine. The decrease in holding power of common spikes in loblolly pine in knots is as great as 25 per cent. Screw spikes under the same conditions increase their resistance about 35 per cent., as the tendency is to pull out the whole knot which they penetrate.

A proposal has been made to provide, in the course of the reconstruction of San Francisco, an elevated road extending from Kearney street down Market street to the Ferry Building. On this portion of the city's main thoroughfare the traffic is very heavy, and the street at present has four lines of street cars. In the present proposition it is suggested to retain the use of the roadway for the street cars and heavy traffic, and to build an elevated road of steel and concrete for the accommodation of the lighter vehicular and the passenger traffic.

The Boston steamers of the Merchants' & Miners' Transportation Company are to be equipped with the De Forest wireless telegraph system.

Testing Alternating Current Apparatus by the Behrend Method (Patented)

In connection with the remarkable performance of the 8000-H. P. frequency changer installed at Shawinigan Falls, Quebec, which, it is claimed, has resulted in the highest efficiency of transformation from 30 to 60 cycles ever attained, it is of interest to note the method devised by B. A. Behrend, chief electrical engineer of the builders, the Allis-Chalmers Company, of Milwaukee, Wis., for testing alternating-current generators and synchronous motors, under full-load conditions, while they are still in the shop. It is not always possible, with the large sizes of units of the present day, to supply the driving power for tests required at full load and at overload, and, therefore, methods of test have been devised in which the driving power is limited to that available in the shops of the manufacturer. The machines must be put under such conditions as lead to full losses in the core and the coils of the machines.

The alternating current, by means of its property of being able to store energy during one-quarter of a period, and return it during the next quarter, allows the flow of large amounts of apparent energy in the form of so-called wattless currents. It is possible, by properly exciting two alternating-current machines operating in parallel, to circulate a large quantity of apparent energy without having to supply more true energy than corresponds to the losses which take place in the machines. Such motor-generator tests, consisting in operating an alternating-current machine as a motor, running idle, have been made by Mr. Behrend for many years, and have been used for the determination of the regulation of alternators on low power factors, as well as of the heating under the same conditions.

But this method of testing requires two machines of the same capacity, and involves the expenditure of power corresponding to the losses of two machines. The first to suggest the circulation of power within a single machine was William M. Mordey in a paper, Volume II., 1893, of the "Journal of the British Institution of Electrical Engineers." Mr. Mordey's method, applied, for instance, to a single-phase generator, having twenty poles on each side of a single exciting coil, would be carried out by splitting the armature into two sections of eight and twelve coils, respectively, and by connecting these sections in opposition so that only four coils would be effective in regard to the circulation of current through the armature. The section of the armature which contains eight coils acts as motor, while the section containing twelve coils acts as generator.

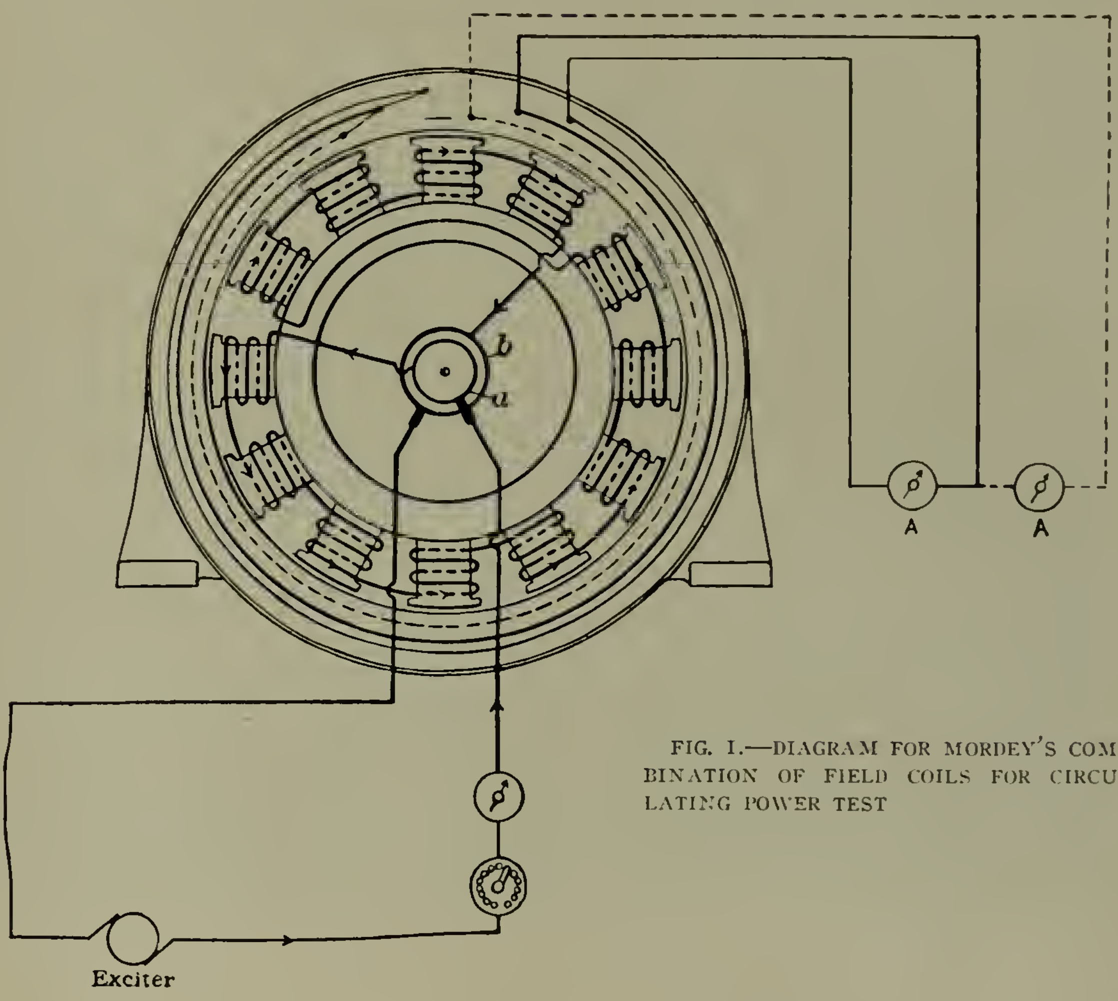


FIG. I.—DIAGRAM FOR MORDEY'S COMBINATION OF FIELD COILS FOR CIRCULATING POWER TEST

The current which circulates through the armature coils is almost in quadrature with the resultant e. m. f., and is, therefore, a wattless current. Hence, the eight poles of the motor section of the machine will be strengthened by the armature current, whereas the twelve poles of the generator section of the machine will be weakened by the same current. This leads to a magnetic unbalancing of the machine, as the motor fields carry more resultant flux than the generator fields. In Mordey's machine, this condition may not have caused trouble, as his machine does not contain iron in the armature; but in modern generators his method cannot be used on account of the magnetic unbalancing of the ma-

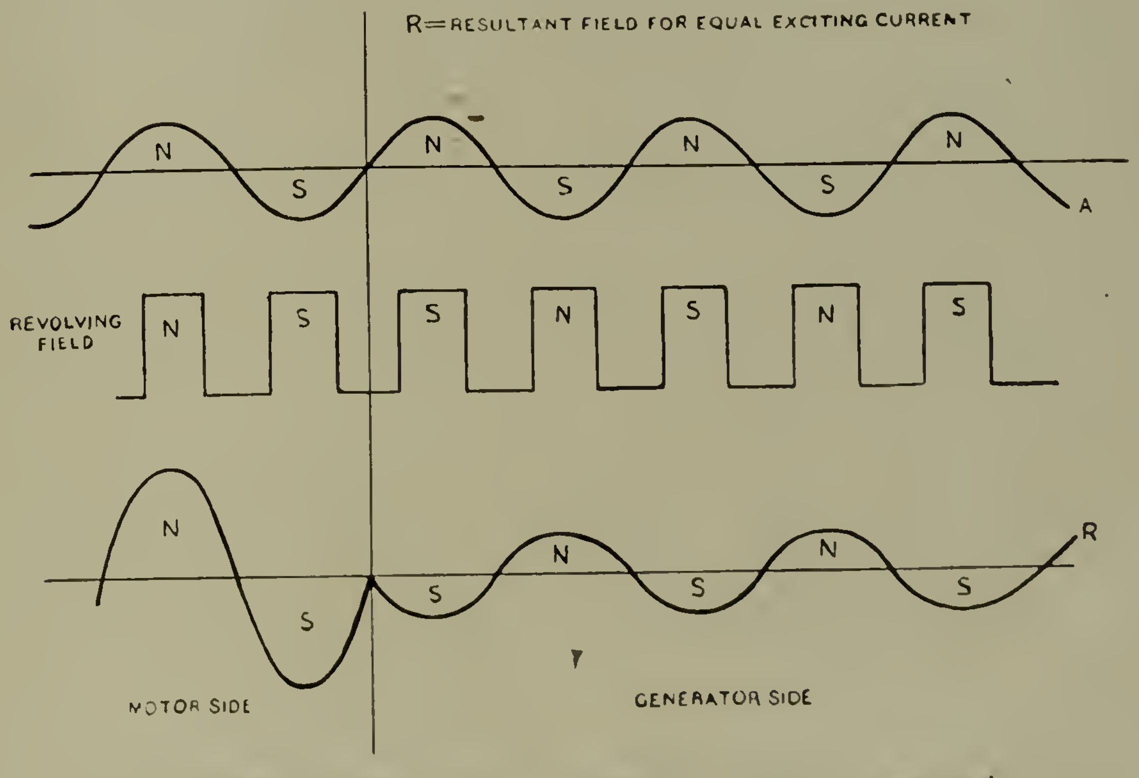
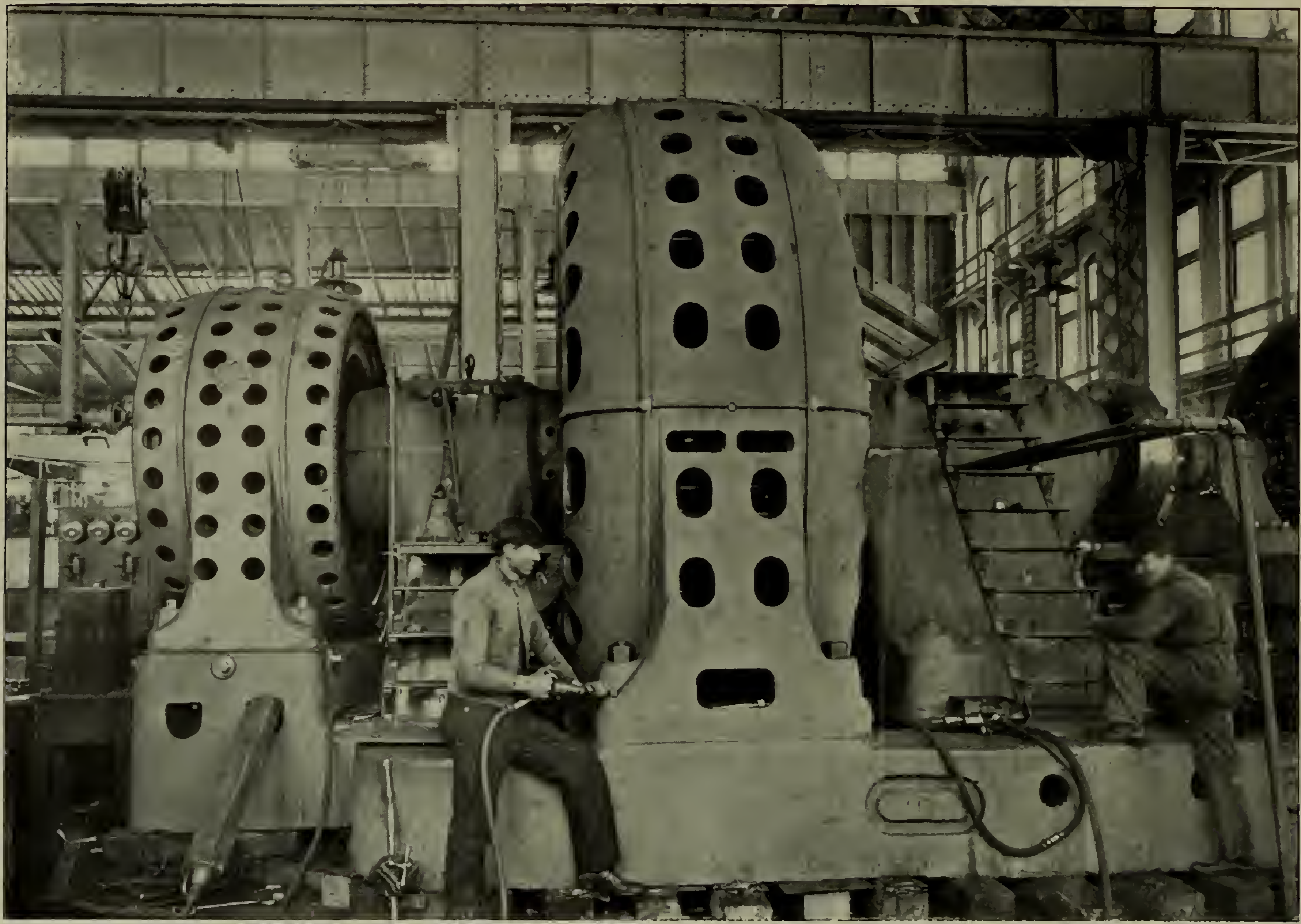


FIG. 2.—DIAGRAM SHOWING EFFECTS OF ARMATURE CURRENTS IN MORDEY'S TEST



AN 8000-H. P. ALLIS-CHALMERS MOTOR UNDER FULL-LOAD TEST BY THE BEHREND METHOD. THIS MOTOR IS CLAIMED TO BE THE LARGEST EVER BUILT, AND FORMS PART OF A FREQUENCY CHANGER INSTALLED AT SHAWINIGAN FALLS, QUEBEC

chine. Instead of dividing the armature into two sections and connecting these sections in opposition, it naturally suggests itself, especially on polyphase machines of the revolving-field type, to split the field into two sections and to connect these sections in such a manner that the electromotive forces induced in the armature are in opposition. This method cannot be carried out in practice, as the machine vibrates and jars in a manner which makes its operation under such conditions impossible.

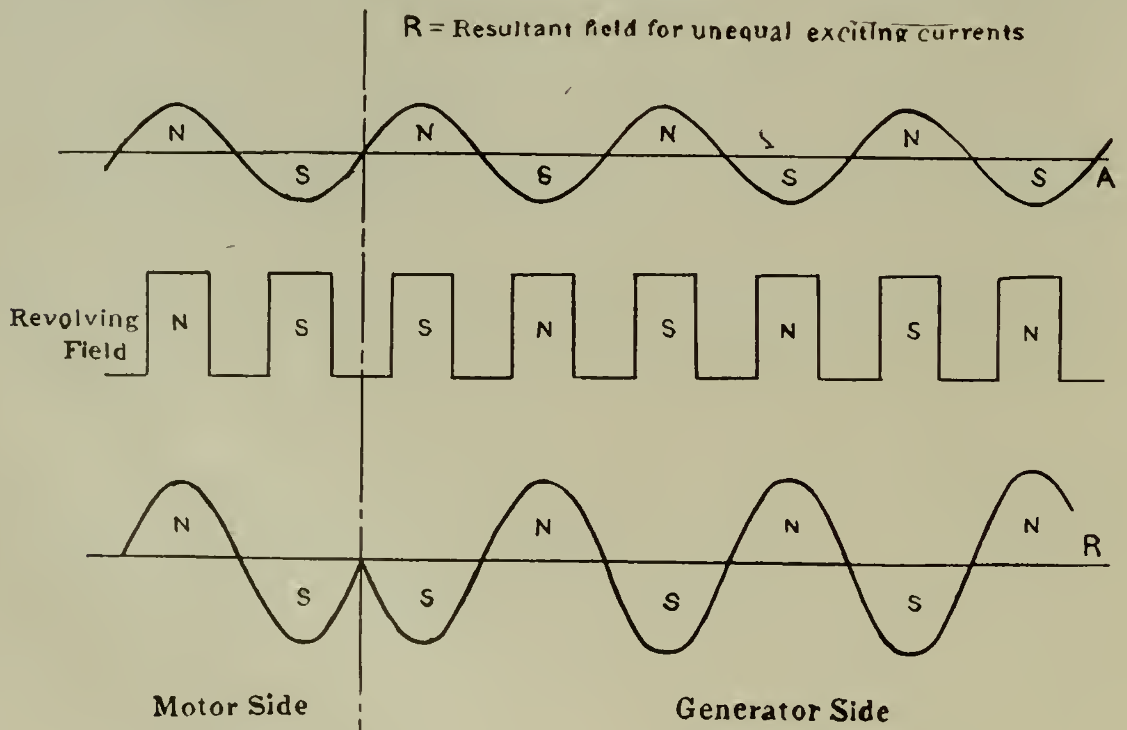


FIG. 3.—DIAGRAM SHOWING EFFECTS OF ARMATURE CURRENTS IN BEHREND'S SPLIT-FIELD TEST

Referring to Fig. 1, which represents Mordey's combination of field coils, it will be seen that the current in the armature strengthens the field of the poles which act as motor and weakens the field of the poles which act as generator, as represented in Fig. 2.

The magnetic attraction between the revolving and stationary parts being proportional to the square of the induction in the air-gap, it is seen from Fig. 2 that the conditions of operation are impossible, on account of the unbalanced magnetic forces.

In order to circulate power successfully within a single machine, it is thus essential to obtain uniform induction in the air-gap of both the motor and the generator poles. As the armature reaction strengthens the motor poles and weakens the generator poles, the impressed excitation of the motor poles must be smaller than the impressed excitation of the generator poles, and this can be effected as shown in Fig. 4, by splitting the field coils into two sets of an equal number, excited with different field currents. Fig. 3 shows the effect of the armature reaction on the poles. In both Figs. 2 and 3 the wavy line *A* represents the field produced by the armature current alone, and the wavy line *R* represents the resultant magnetic field.

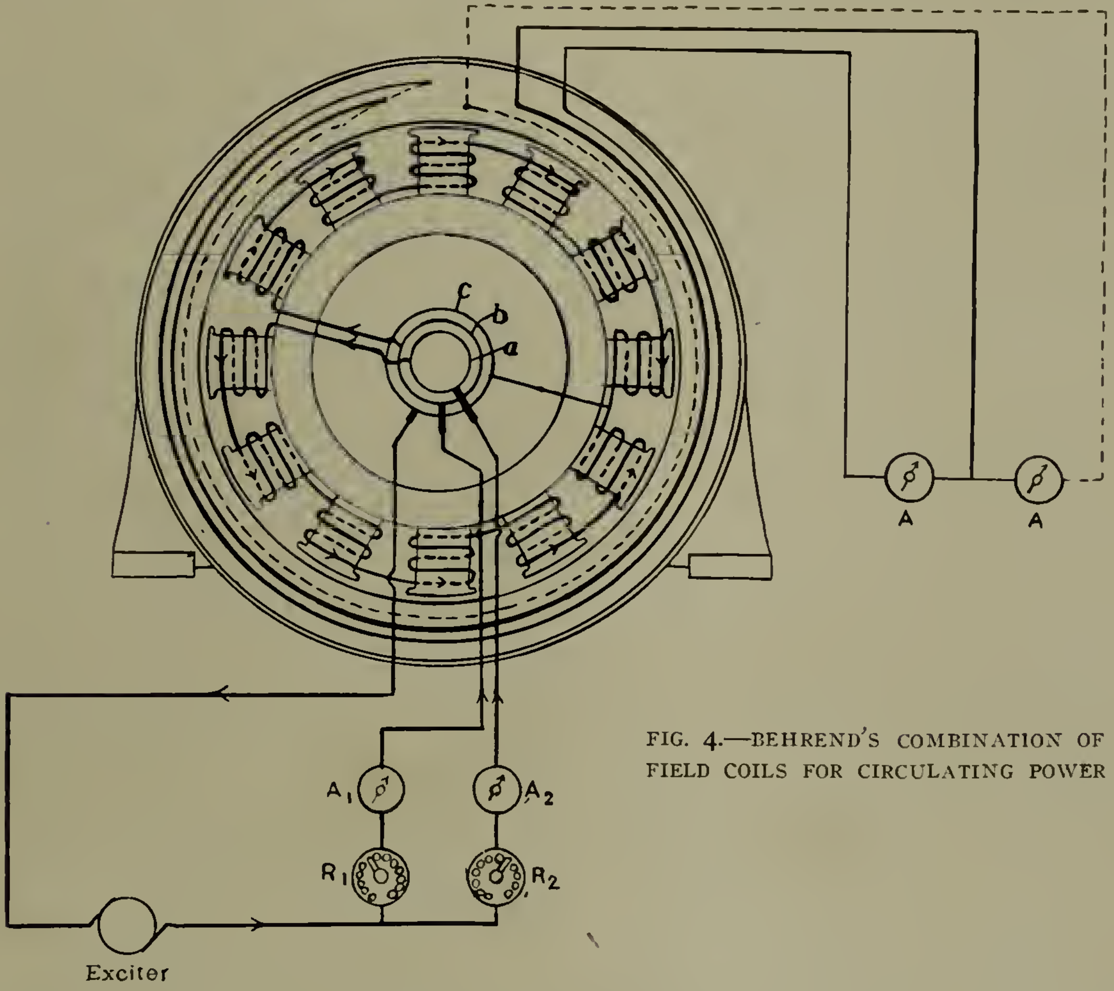


FIG. 4.—BEHREND'S COMBINATION OF FIELD COILS FOR CIRCULATING POWER

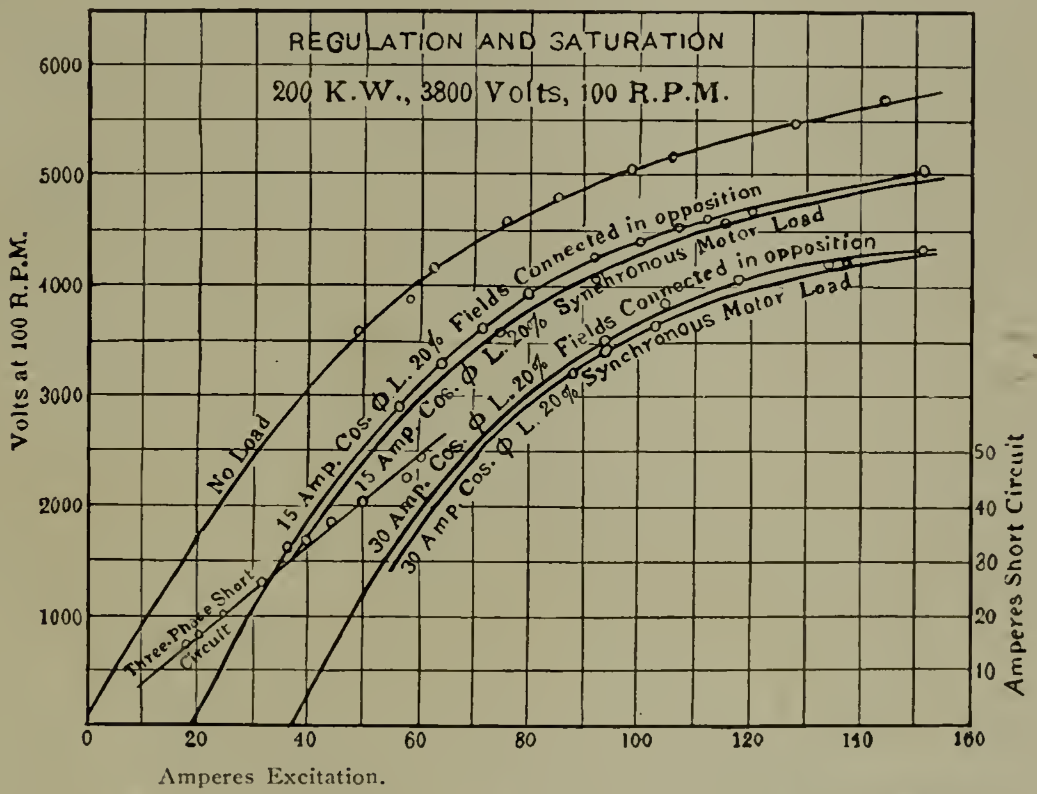


FIG. 5.—COMPARISON BETWEEN REGULATION CURVES OBTAINED BY THE SYNCHRONOUS MOTOR-GENERATOR TEST AND BY THE BEHREND METHOD

Fig. 5 represents the regulation curves on low power factor obtained by first running a synchronous motor from the generator, and, secondly, by circulating power within the machine itself. The agreement between the two methods is very satisfactory. On machines designed by Mr. Behrend numerous experiments have been made to check the new method against the synchronous motor-generator tests, and the results have shown a very close agreement.

Fig. 8 shows the regulation curves of a 3000-KW., 26-pole, 50-cycle generator obtained in this manner. Fig. 6 shows the regulation curves of a 3200-KW. fly-wheel type, 96-pole, 60-cycle generator. Fig. 9 shows the regulation curves of a 3500-KW., 40-pole, 25-cycle generator, forming a part of the unit known as the "Big Reliable," which supplied power and lighting current to the World's Fair at St. Louis. The terminal voltage corresponding to the conditions under which the machine is operating in the test can be determined by measuring the volts on a set of coils per pole multiplied by the total number of coils, or by adding to the excitation on the motor fields the excitation required to drive the armature current through the armature winding. Both methods have invariably given the same results.

Numerous tests have been made to ascertain the actual losses in operating the machine in the manner described by splitting the field. Fig. 6 shows the comparison between the core loss of the machine, as determined in open circuit run, with losses as obtained in the split-field test; one set of readings is shown by the open dots, the other by the dark ones. These tests were carried out on a 1000-KW., 25-cycle, 32-pole generator.

The heat runs obtained by this method on the machine referred to in Fig. 9 and on a 3200-KW. machine, at full normal load in kilovolt-amperes and power factor zero, yielded the following results:—

HEATING TESTS

	3500 KW.	3200 KW.
Volts	6,600	4,500
Revolutions per minute	75	75
Frequency	25	60
Hours	18	23
Loads, K. V. A.	3,500	3,870
Temperature rise, degs. C.:		
Armature surface	30	27.5
Armature coils	34	31.5
Field coils	34	31.5

It is difficult to imagine a simpler method of testing than the new method described. The course of evolution in engineering has always been from the complex towards the simple. It has taken many years to evolve this method of testing which enables us to obtain with comparative ease the most important data of the performance of alternating-current generators.

The only drawback of the method consists in the fact that it is applicable only to machines having a comparatively large number of poles. It has not been successfully applied to machines having fewer than eight poles. The application of this method is confined to machines of the slow-speed type, and with the advent of the steam-turbine generator new methods will have to be devised to produce artificially full-load losses without the expenditure of full-load power.

It is proposed to connect the peaks of Mount Lowe and Mount Wilson, near Los Angeles, Cal., with a trolley road.

High Tension Lightning Protection

By C. R. McKAY

A Paper Read Recently Before the Central Electric Railway Association

THE most serious obstacle to the continuous operation of interurban railroads and transmission plants to-day is the interruption of their high-tension transmission lines and apparatus connected thereto by lightning discharges and disturbances of a similar nature. Interurban railways are naturally more exposed to interruption from lightning than city roads, and since the transmission line links together the entire electrical apparatus of the system, interruptions or damages thereto may, and occasionally do, put the entire road temporarily out of service, and cause heavy loss. Heretofore the protection afforded by any known methods or apparatus has not been wholly satisfactory, either to the operating companies or to the manufacturing companies.

The report of the National Electric Light Association committee on protection from lightning during 1905, which segregates data of high-voltage (10,000 and upwards) from low-voltage plants, is a long step in the right direction, and furnishes information of a most interesting and practical character. Twenty-nine high-voltage plants reported, aggregating 140,500 kilowatts of capacity. Thirty-eight per cent. of those plants, aggregating 60 per cent. of the total capacity, suffered serious damage during 1905. Thirty-five per cent. of the total 1100 miles of transmission line suffered serious interference, and but 39 per cent. escaped interruption. Forty-five per cent. of the companies using choke coils suffered serious damage, an equal portion escaping. Thirty-three per cent. of the companies not using choke coils suffered serious damage, 67 per cent. escaping.

The figures as to the use of overhead ground wires for protection of pole lines are not very conclusive. In reply to inquiries as to whether their high-tension arresters were satisfactory, 35 per cent. answered yes, and 65 per cent. answered no. Of those answering yes, 78 per cent. had suffered no damage. Of those answering no, 53 per cent. had suffered serious damage.

The report shows clearly, as to high-tension lightning protection, that great improvement is still possible in devices for this purpose. It also indicates that the companies reporting on high-tension plants formed their conclusions more largely from the mere absence or occurrence of trouble than from an actual study of the conditions affecting the success or failure of the protective devices. This is but natural, and the cause and remedy, therefore, will be considered later.

To most of us the word "lightning" means a visible discharge of electricity between clouds or between a cloud and the earth. This impression is incomplete and misleading.

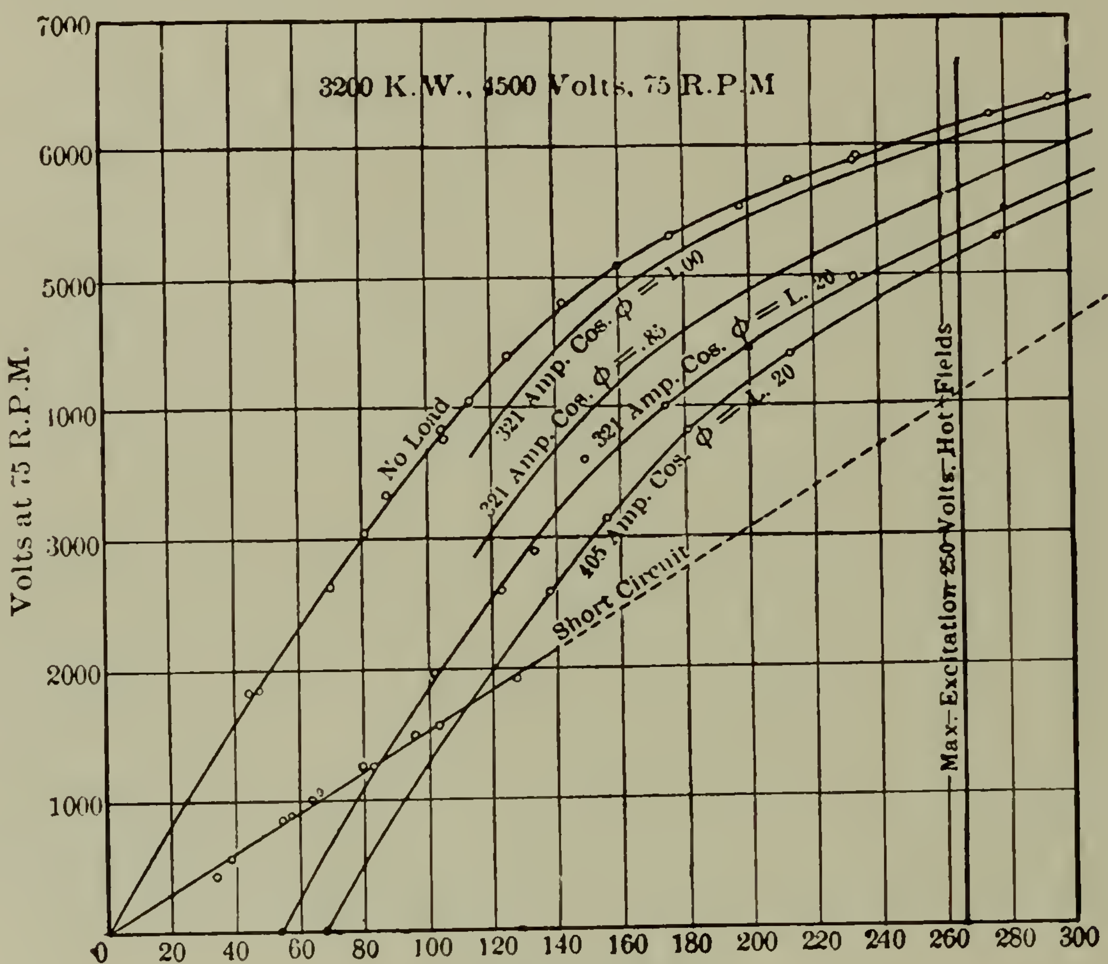


FIG. 6.—REGULATION CURVES FROM A 3200-KW. ALTERNATOR. SEE PAGE 393

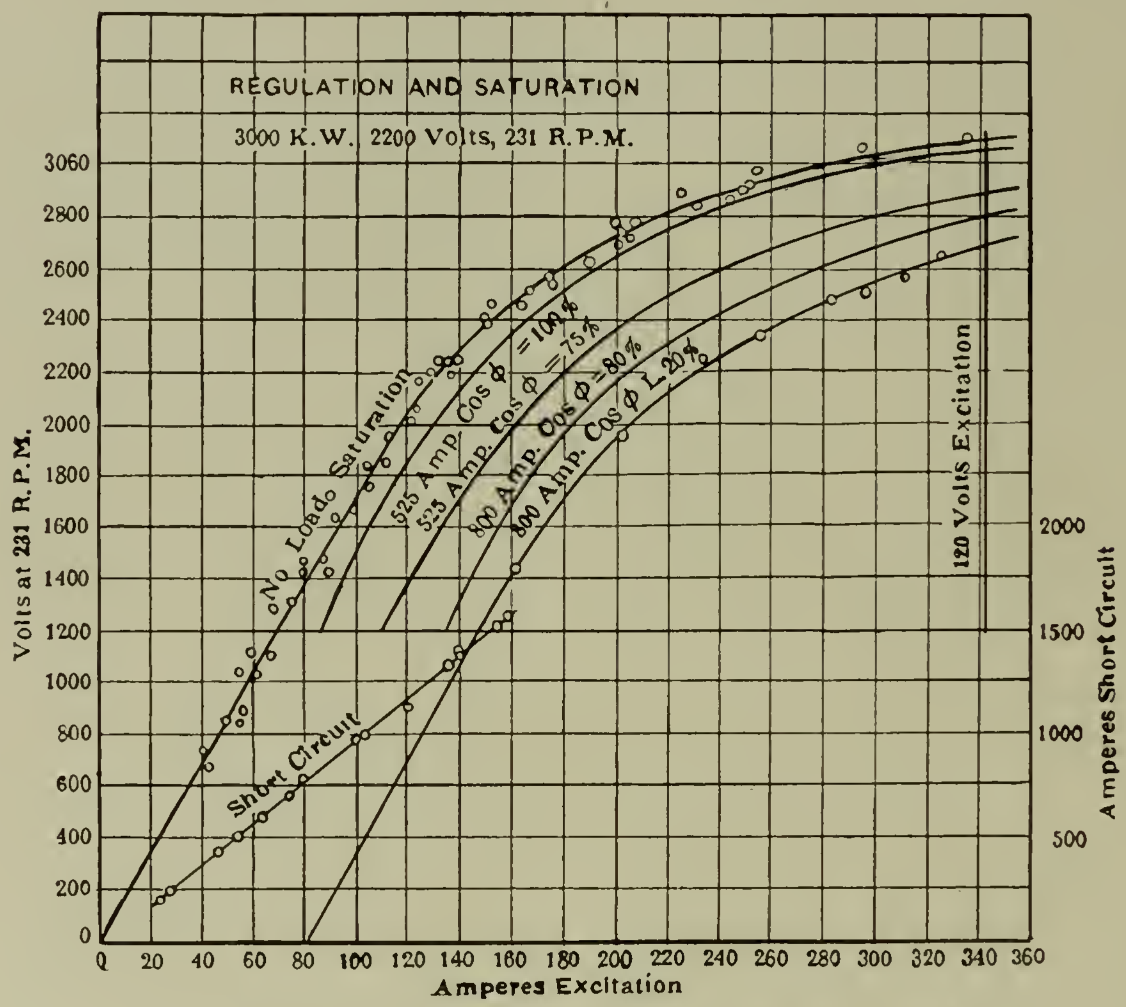


FIG. 7.—REGULATION CURVES OBTAINED FROM A 3000-KW. ALTERNATOR BY THE BEHREND METHOD

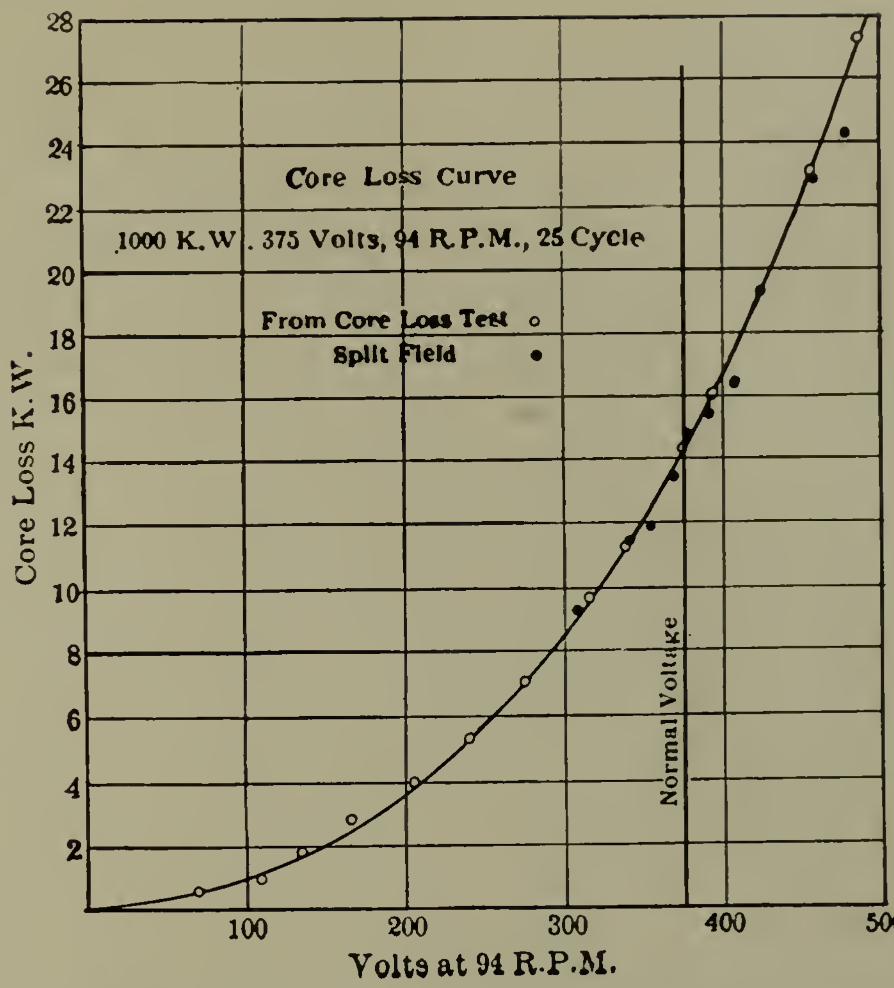


FIG. 8.—COMPARISON OF CORE LOSSES OBTAINED ON OPEN CIRCUIT AND IN THE BEHREND SPLIT-FIELD TEST. SEE PAGE 393

Dr. C. P. Steinmetz has defined lightning as being any abnormal voltage condition on a transmission line, whether produced by atmospheric electricity or by internal abnormal surges of electricity. Observation shows that the internal conditions of a circuit may be such as to respond, with a dangerous internal surge, to a light, harmless inductive stroke from a cloud. Atmospheric electricity may become manifest either in gradual static accumulations, due to wind, rain, induced charges, or a direct stroke. Static induction may charge the line to an abnormal voltage, whether produced by cloud lightning or by the sudden charging of an adjacent line. Surging or the creation of voltage waves of excessive maximum values may be caused by the opening of a switch on a loaded line, by voltage waves of higher frequency than the impressed voltage, by arcs between the line and isolated conductors, or between one phase and the ground, by short-circuits in transformer or generator coils, or, again, by the sudden interruption of a short-circuit at the instant of the current wave maximum.

The causes producing abnormal voltage effects in transmission circuits develop many different characteristics of discharge. The discharge may vary in frequency from 1000 cycles per second to 1,000,000,000 cycles per second, according to the time element of the circuit traversed by the discharge, and which rarely, if ever, twice has the same constants.

Much laboratory experimenting has been carried out, and much has been learned therefrom, but much must also be learned from experience under actual operating conditions, and that experience hitherto has taught but little because it has not been carefully collected, preserved and delivered to those fitted by training and study for the logical deduction of profitable conclusions therefrom.

There is a large field of investigation in which the operating engineer, as well as the manufacturer, should work. The laboratory cannot include in its equipment leagues of transmission line, thousands of kilowatts of apparatus, dozens of voltages and frequencies, and real lightning storms with a hundred observers for each.

Among the principal high-tension alternating-current protective devices in present use are overhead grounded wires, series resistances and air gaps with and without resistances.

GROUNDED WIRES

The advisability of installing overhead grounded wires depends largely upon the particular conditions of each individual system. Opinion is much divided as to their effectiveness, but there seems good reason to believe that when properly installed and frequently grounded they do offer a material degree of protection to the pole line itself as distinguished from the apparatus connected to the transmission line. Its use involves high first cost, and its value would be doubtful in protecting a transmission line constructed upon steel supports properly grounded.

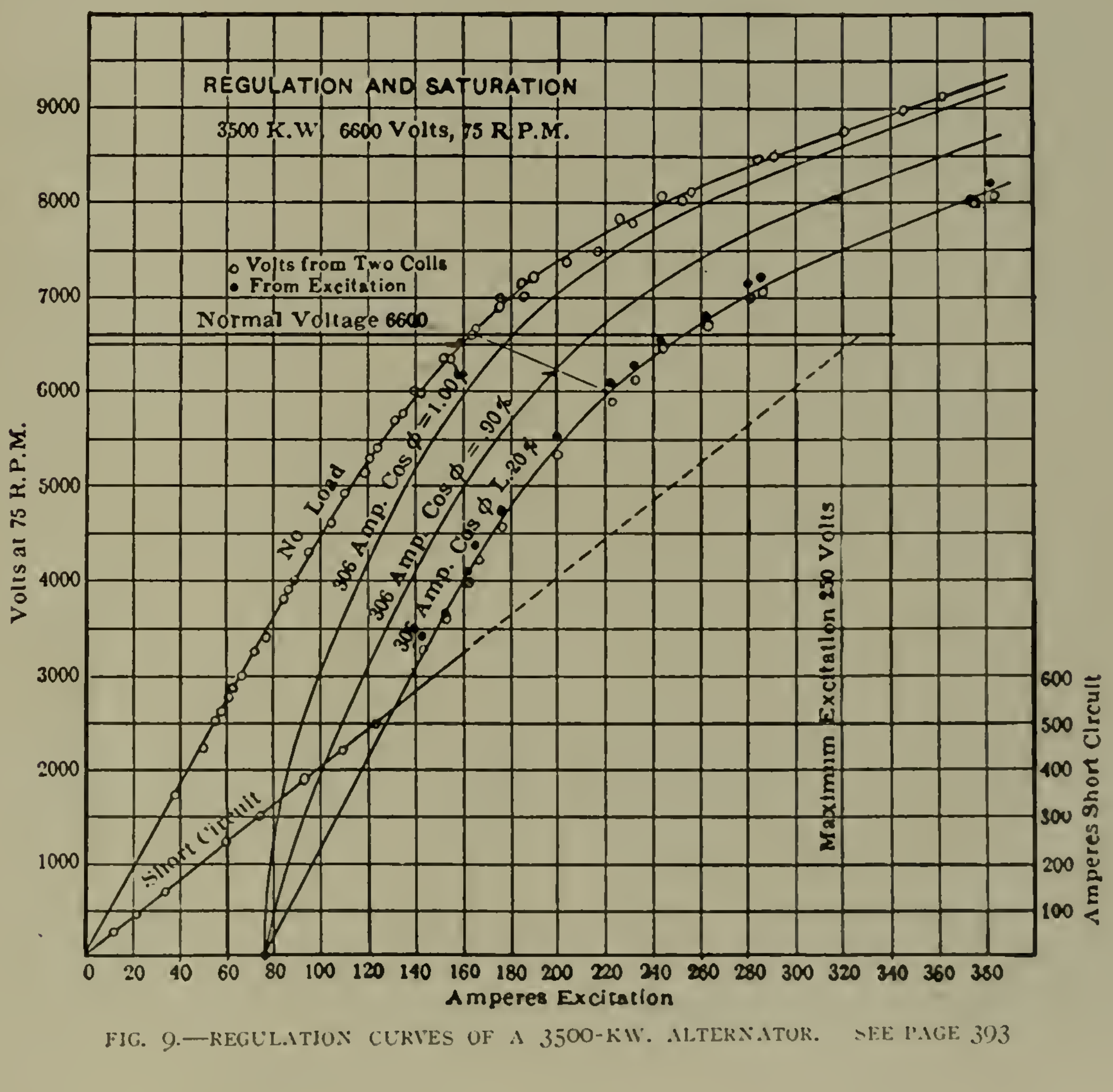


FIG. 9.—REGULATION CURVES OF A 3500-KW. ALTERNATOR. SEE PAGE 393

WATER STREAMS

The series resistance arrester in one prominent form consists of grounded streams of water directed against the transmission wires. This type of arrester seems to have little value in protecting apparatus against high-frequency disruptive discharges; it is effective, however, in discharging gradual static accumulations. The stream has variable resistance and presents objectionable inductance to high-frequency discharges.

AIR GAP AND RESISTANCE TYPES

Both abroad and on the Pacific Coast the horn arrester, with and without resistance, is much used. This type without resistance will maintain an arcing short-circuit lasting several seconds, causing bad line surges and throwing out of step synchronous apparatus connected to the line. When used with series resistance the results are improved, but the use of series resistance offers the serious disadvantage of inability to successfully pass a heavy discharge. Under a light discharge it will generally operate satisfactorily, and by limiting the flow of current will aid in extinguishing the arc across the air gap. Series resistances, furthermore, generally possess considerable impedance, thereby tending to force the discharge across some alternative path with possible resulting damage to apparatus.

The multigap arrester when used without resistance is objectionable in that it offers very little, if any, obstruction to the unlimited passage of current when the arc has been once established across the gaps. The fundamental feature of the present form of multigap arrester is a series of metallic cylinders of less than 1 inch in diameter placed side by side with spark gaps of about 1-32 inch intervening.

When a shunt resistance is used in conjunction with a series resistance, it is customary to reduce the value of the series resistance and thus detract slightly from the common faults of the multigap series resistance type. For light discharges both the series and shunt resistance will be operative, and for heavy discharges the shunted gaps are automatically cut in. The addition of the shunt resistance does not, as stated above, eliminate entirely the troubles encountered with the plain series resistance. The fact still remains that we have a series resistance, which itself offers considerable opposition to heavy discharges.

In using the shunt resistance without the series the best condition of affairs is approached because all light strokes traverse the shunt resistance, whereas a stroke of large quantity and high frequency will balk at the inductive path afforded by the resistance at high frequency, and will discharge across the shunted gaps. The shunt resistance, if properly adjusted, will extinguish the arc in the shunted gaps and the shunt resistance then acts in series with the series gaps to interrupt the line current. It should be noted that the shunt resistance comes into action only after the lightning stroke is past. Shunting a large percentage of the gaps with just sufficient resistance to prevent excessive current from flowing across the series gaps under ordinary discharges, and to serve as a by-pass for the excessive current accompanying a heavy discharge, seems to satisfactorily meet the requirements.

A gradual elimination of arrester types, proved ineffective by experience under the excessively severe tests of high-voltage transmission, has left but two or three types for serious consideration. The multigap type is most generally favoured, and nearly all lightning protection for voltages exceeding 600 is effected by devices based upon the multigap principle in combination with resistance. The chief improvement made during the present year in this type of arrester has been the construction and adjustment of the shunt resistance.

In the multiplex arrester a path from line to line is provided with the same number and arrangement of gaps and resistances as from line to ground. Observations made to determine the advantage of the multiplex connection show that frequently the high-potential disturbances pass from line to line across the multiplex connection, thus equalizing abnormal strains between lines, without traversing the gaps to ground. In circuits having considerable resonance it is sometimes necessary to increase the number of gaps between line and line to reduce the danger of an arc forming and holding over the line gaps.

The design of the multigap arrester without series resistance fulfills all laboratory requirements, and provides greater security under operating conditions than previous types. It protects from minor static disturbances, as well as being always ready for the severest surge or external stroke, and approaches a practical solution of the lightning and static strain problems which now influence long-distance transmission systems.

GROUND WIRES

It is pertinent to refer to the grounding of protective apparatus, although in recent years much improvement has been made in this direction. Its importance is being more generally realized, but there are many plants wherein the weak link in the lightning protection is found between the visible portions of the "ground circuit" and the earth itself.

Wherever possible the ground wire should be straight, and, therefore, the ground itself should be directly under the lightning arrester. In designing a new power station, this condition can generally be made possible, and care should be taken to do so. In older stations with grounds already installed at some distance from the arrester, it is advisable to make an auxiliary earth connection as nearly beneath the arrester as possible. This is advisable even though the resistance of this auxiliary earth may considerably exceed that of the main earth.

The ground wire should be attached to a copper plate having an area of at least 4 square feet, embedded in charcoal or coke and surrounded by moist earth. The earth surrounding the pit containing the coke can be kept moist by embedding a vertical perforated iron pipe in the coke. The ground wire may run down the side of this iron pipe and the plate may consist of a copper strip about 6 inches wide and as long as convenient bent lengthwise around the pipe. Either ground wire or plate may be soldered to the iron pipe. Water can both drain and be poured into the perforated pipe and will percolate through the soil and coke, keeping the "ground" perfect under most adverse circumstances.

DATA REGARDING PERFORMANCE

Generally speaking, we lack conclusive data showing the specific values of various high-tension protective devices, the causes of failures, the relative liability to trouble with various voltages, frequencies, topographies and methods of construction. More particularly is our knowledge limited as to what actually occurs, where and when a lightning disturbance takes place. We must thoroughly understand the nature of the disease before we can cure it.

The manufacturer seeking among operators for accurate information on these matters finds it almost impossible to obtain consistent or valuable statements. Different operators utilizing identical protective apparatus under apparently similar conditions give wholly contradictory reports regarding their effectiveness. Companies having the least trouble frequently assume that they have the best protection. No assumption could be less justified. The remedy for this condition lies chiefly in the hands of the operating staffs of the stations and the transmission lines.

It cannot be questioned that the existing lack of practical data covering these matters has been due to the failure of the operating companies to record and preserve it, and this failure is doubtless due largely to a lack of understanding on the part of operators and their employees as to just what information is requisite and valuable. It is hardly conceivable that operators would be so blind to their own interests as to neglect this question, were they fully posted as to the character of information required and the ease of obtaining it.

The labour involved in taking and recording the necessary observations is negligible, and technical knowledge is unnecessary. What is wanted are certain facts visible to the operating employees of stations and lines. These men are the ones who see the phenomena at first hand and the men first on the spot after a breakdown, and it is only through the data thereby obtained that a true conception can be obtained of the nature of the discharge and the causes of such failures as occur.

The importance of getting the information immediately at first hand in some suitable shape for future tabulation should be clearly realized. It is desirable and essential to distinguish between the actual observations and the conclusions that may be drawn from these observations; in their relative importance detailed evidence stands first, opinion second.

The universal adoption and use of a suitable information blank covering the nature of each disturbance witnessed would, when answered, compiled and tabulated into a suitable report, provide a vast quantity of data immediately useful in determining the best method of installation and the most suitable device to meet the conditions of any particular system.

The use of telltale papers, properly located in the arresters and perhaps operating with a time movement, will be of great value in connection with the other observations, especially in furnishing some record of occurrences taking place in too rapid sequence for the eye and brain to catch and note them. In no other manner can so much valuable information on the subject be so quickly obtained and so effectively utilized. The advantage of the method lies in speedily securing a large amount of practical information with correspondingly quick benefits by the elimination of devices proved ineffective and by materially aiding the improvement of existing devices and the production of new and thoroughly efficient ones.

The class of information which is important to obtain includes details of the following:—

A description of the system covering its general arrangement, its geographical and topographical features; station apparatus, power lines, protective apparatus, character of apparatus protected, character of operating mechanisms, observations of the discharge, location of discharge and accompanying phenomena.

A committee has been appointed by this association for the express purpose of providing the members and their employees with specific information as to the data necessary to make an intelligent report of lightning and similar disturbances, and to provide an information blank for continual use by employees during the coming season in recording occurrences of the kind under consideration. The committee will classify and summarize the reports, placing the resulting data freely before the members of this association and the manufacturers of protective apparatus. The manufacturers will utilize this data toward the improvement of their protective devices.

At Gysinge, in Sweden, during the year ending May 31, 1906, from a Kjellin electric furnace giving one ton (240 pounds) of steel per tap, there was produced 950 tons of tool steel and special steel ingots. In carbon and iron tool steels all the usual tempers were made. The bulk of this steel was made from charges composed of about 80 per cent. of Swedish white pig-iron and 20 per cent. of steel scrap. The percentage of carbon was regulated by the addition of briquettes. Other charges were made from Swedish white iron and steel scrap. The average time taken per charge for the year, when adding briquettes, was seven and one-eighth hours, and the electric energy consumed was 1128 units (kilowatt hours) per ton. The average time per charge for white iron and scrap charges was five and one-half hours, and the electric energy consumed was 886 units per ton. The consumptions include all time and energy lost from various causes, such as bad water supply, ice, etc.

Book News

Designs for Small Dynamos and Motors

By Cecil P. Poole. Published by the McGraw Publishing Company, New York. Size, 6½ by 9½ inches; 186 pages; 231 illustrations. Price, $2.00.

Most of the chapters of this interesting book originally appeared as articles in "The American Electrician," and many of them have been published in the book entitled "Electrical Designs." Chapters X. to XVIII., inclusive, however, have not previously appeared in book form. All the direct-current designs in the book have been revised in accordance with the changes in the practice in dynamo and motor design which have occurred since their first publication.

The book is not at all theoretical, but gives the dimensions of various parts of a number of different sizes of machines, with directions for machining and assembling them. The machines dealt with vary from a 1-6-H. P. motor to a 4-KW. combined alternating and direct-current machine. The book should prove a valuable one for amateurs who have the means and the facilities for building their own machines.

Stray Currents from Electric Railways

By Dr. Carl Michalke. Translated by O. A. Kenyon. Published by the McGraw Publishing Company, New York. Size, 6 by 8 inches; 108 pages; 34 illustrations. Price, $1.50.

According to the translator's preface, this book was compiled from reports on electrolysis in various European periodicals, these reports being inspired by the accounts of the "horrible" cases of electrolysis on this side of the water. An extensive bibliography and a few foot-notes from American practice have been added by the translator.

In the first chapter, stray currents with uniform current load on the rails are considered, and formulæ are obtained for the total leakage current and the potential difference between earth and rail. In the next chapter, a uniformly increasing current load on the rails is also treated mathematically. The resistance of the rails, the earth, pipes, mortar and concrete, and water in pipes is next considered.

Three chapters are devoted to corrosion and a number of pages to the taking of measurements. In the chapter on preventive measures, the author suggests the use of heavy rails and keeping the bonds in good condition. Rails should also be thoroughly bonded at crossing points and switches. Track resistance should be kept low and pipe resistance increased as much as possible. Cast-iron pipes should be used in preference to wrought iron. Insulating the rails and pipe lines and reversing the polarity of the current are suggested.

Other disturbances caused by stray currents, as in physical instruments, telephones, telegraphs and signal apparatus, are also discussed.

A Graphical Treatment of the Induction Motor

By Alexander Heyland. Translated by G. H. Rowe and R. E. Hellmund. Published by the McGraw Publishing Co., New York. Size 6 by 8 inches; 48 pages; 28 illustrations. Price, $1.00.

The object of the method described by the author is the experimental determination of the characteristic properties of induction motors. The method consists essentially in the practical application of the circle diagram, first described by the author in the "Elektrotechnische Zeitschrift," in 1894.

The general theory of the induction motor is first taken up, the circle diagram is then discussed, and by means of it the theoretical determination of input, output, torque and slip. To show the agreement between the theory and practical tests, the practical application of the diagram is then taken up. Several sizes of motors are also considered, characteristic curves being plotted and values obtained of efficiency, input, output, power factor, and slip.

The induction motor as a generator, and the use of the circle diagram in obtaining the characteristics under this condition, is next dealt with. The book concludes with a discussion of single-phase induction motors, a method being given for obtaining the diagram of this type from that of the polyphase.

Handbook of Mathematics

By J. Claudel. Translated by O. A. Kenyon. Published by the McGraw Publishing Co., New York. Size 6½ by 9½ inches; 708 pages; 422 illustrations. Price $3.50.

The need for compiling the matter in this book is, perhaps, best expressed in the preface, as follows: "If a busy man wishes to solve an integral which is not given in the table, he naturally refers to his college text-book on integral calculus, spends several hours studying, and finds that his trouble is further back, most likely in algebra; then the chances are that, due to lack of time, he will give up and declare that he has forgotten his calculus." This trouble has been anticipated in the handbook by the frequent use of cross references. The translator has added chapters on United States weights and measures, annuities, insurance, bank discount, and the like.

To attempt to tell all that is given in the book would be impossible here. Suffice it to say that it deals with the mathematical processes in arithmetic, algebra, geometry, trigonometry, analytical geometry, and calculus, which are likely to be of service to the engineer and engineering students.

National Electric Light Association

At a recent meeting of the executive committee of the National Electric Light Association, the matter of offices in the United Engineering Building was formally decided. The association will change its headquarters as soon as practicable after the new building is ready for occupancy. There was an unusually full attendance at the meeting, and several important measures were set in motion.

Among the new applications for membership passed upon and approved were the following:

CLASS A

The North Georgia Electric Company, of Gainesville, Ga.

The Millville Electric Light Company, of Millville, N. J.

The McCall Ferry Power Company, of New York, N. Y.

The Miami Light, Heat & Power Company, of Piqua, Ohio.

The Laramie Light & Power Company, of Laramie, Wyo.

The Albany Power & Manufacturing Company, of Albany, Ga.

The Toledo Gas, Electric & Heating Company, of Toledo, Ohio.

The Escambia County Electric Light & Power Company, of Pensacola, Fla.

CLASS B

E. J. Fowler, of the Chicago Edison Company, Chicago, Ill.

J. W. Murray, of the Allegheny County Light Company, Pittsburg, Pa.

A. S. Allen, of the Tonawanda Power Company, Tonawanda, N. Y.

G. H. Patten, of the Chattanooga Electric Company, Chattanooga, Tenn.

Arthur L. Linn, of the Rochester Railway & Light Company, Rochester, N. Y.

E. A. Phinney, of the Ouray Electric Power & Light Company, Ouray, Ohio.

Henry Stephenson, of the New York Edison Company, New York, N. Y.

J. W. Young, of the McCall Ferry Power Company, New York, N. Y.

H. M. Edwards, of the New York Edison Company, New York, N. Y.

Charles S. Shepard, of the New York Edison Company, New York, N. Y.

William S. Dupont, of the Public Service Corporation of New Jersey, Newark, N. J.

James T. Whittlesey, of the Public Service Corporation of New Jersey, Montclair, N. J.

J. Kennedy, of the Public Service Corporation of New Jersey, Weehawken Heights, N. J.

Edward J. O'Beirne, of the Gainesville Electric Railway & Light Company, Gainesville, Tex.

CLASS D

Michaelis & Ellsworth, of New York, N. Y.

Roderick J. Parke, of Toronto, Canada.

The Lundin Electric & Machine Company, of Boston, Mass.

The Condit Electrical Manufacturing Company, of Boston, Mass.

The Shelby Electric Company, of Philadelphia, Pa.

CLASS E

James D. Ellsworth, of Michaelis & Ellsworth, New York, N. Y.

Concerning the proposed electric line between New York and Chicago, "The Wall Street Journal" says: "Prominent railroad engineers have given the question serious consideration, and a practically unanimous verdict has been rendered that the scheme is impracticable. Did the plans look feasible to the large financial interests, the offering of stock at 25 cents on the dollar would not be necessary. We do not consider the stock a good purchase. It is essentially speculative, and looks more like a catch-penny scheme than a 'safe and sane proposition.'"

By adding metals like potassium, sodium, lithium, calcium, etc., to the mercury, the spectrum of the mercury arc can be changed. The practical application for the purpose of improving the colour of the mercury arc meets, however, with considerable difficulties and disadvantages, such as the attack on the glass by the alkali metals, the lowering of the efficiency, etc.

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New York, December, 1906

The Electrical Age Co.
New York and London

The New Power Plant of the Vermont Marble Co.

By H. S. KNOWLTON

THE industrial plant of the Vermont Marble Company is justly famous as one of the largest establishments of its kind in the world. A large demand for cheap power exists in the marble quarry and in the mill where the product of the hills is treated and shaped to meet the varying requirements for architectural, electrical and other purposes. An extended use of electricity has, therefore, been made in localities where this class of power is readily available.

At the headquarters of the Vermont Marble Company in Proctor a new power station is now in service, the rated capacity of the plant being 2250 KW.,—a rather unusual size for a private plant. The value of the company's finished product thirty-six years ago was $130,000 per year; to-day it exceeds $3,000,000 per year. Such a growth as this

FIG. 1.—GENERAL VIEW OF THE POWER PLANT OF THE VERMONT MARBLE COMPANY, SHOWING THE SUTHERLAND FALLS IN OTTER CREEK

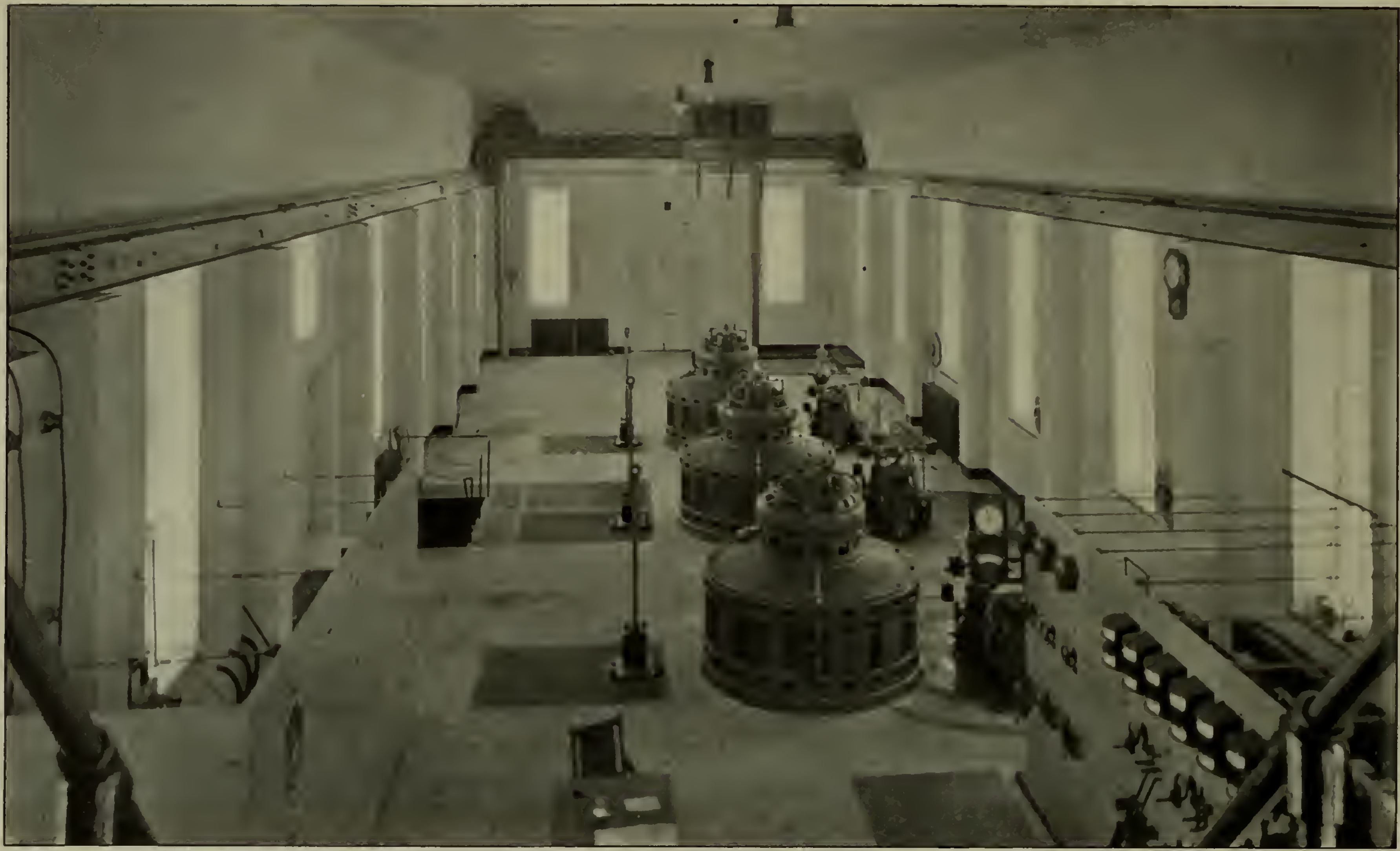


FIG. 2.—INTERIOR OF THE POWER HOUSE OF THE VERMONT MARBLE COMPANY AT PROCTOR. THREE 750-KW., 3-PHASE GENERATORS, BUILT BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y., ARE DRIVEN BY TURBINES BUILT BY THE I. P. MORRIS COMPANY, OF PHILADELPHIA

has necessitated increased power facilities, as well as enlarged equipment in other directions.

The power plant is located on Sutherland Falls, Otter Creek, about 500 feet east of the company's principal mills. The company shares various water privileges in the town of Chittenden, near Rutland, with the Rutland Railway, Light & Power Company. The discharge of the Chittenden water-shed traverses this section of the country in the stream known as Otter Creek. The power house, shown in Fig. 1, is built at the bottom of a large gorge, and a head of 110 feet is available at the water-wheels.

FIG. 3.—A NEARER VIEW OF ONE OF THE GENERATORS AND A WATER-WHEEL GOVERNOR

The building is a marble structure supported on concrete foundations, there being one story and a commodious basement in the plant. The power house is 95 feet long and 33 feet wide. It is built large enough to house four 750-KW. units, although only three are as yet installed. The completed plant will have a floor space of 1.04 square feet per kilowatt of capacity. Fig. 1 also shows the riveted steel penstock which carries the water to the wheels from the dam located 500 feet above the power house, a stairway down the cliff for the use of foot passengers, and an inclined railway which greatly facilitates the handling of materials or supplies between the power house and the upper ground levels. In the foreground is a portion of the old power house and shaft bridge or runway by which power was transmitted mechanically to the marble mill just above.

The penstock is rigidly anchored to concrete piers in its course down the hillside from the reservoir. At the top it is 9 feet in diameter, and composed of 5-16-inch steel plate; beyond the large pier at the summit of the embankment just behind the power house the diameter decreases to 8 feet, the thickness of the plates increasing to ⅜ inch in the 32-degree slope of the pipe towards the power house, and then to 7-16 inch in the 45-degree section before the power house is reached. As each water-wheel is passed the penstock diameter decreases 1 foot, so that at the end of the run, by the fourth wheel, the diameter will be 5 feet.

Enclosed in a wooden tower at the top of the large concrete pier, shown in Fig. 1, is a 9-foot relief pipe, which makes a right-angled connection with the penstock. The relief pipe is anchored into the pier by steel angles.

Fig. 2 is a general view of the power house interior, showing the generating units, lightning arrester compartment on the left and operating switchboard on the right. The switchboard panels are of the company's own manufacture, a large product in this line being turned out annually. The generator room is served by a 10-ton, hand-operated traveling crane, built by the Pedrick & Ayer Company, of Plainfield, N. J. The crane rail is 15 feet above the concrete floor of the generator room, the lift being 35 feet and the span 28 feet 11 inches.

The generating equipment consists of three General Electric 750-KW., 480-volt, 3-phase, 60-cycle, 14-pole, revolving-field, vertical-shaft alternators, each direct connected to a 27-inch Morris 1200-H. P. turbine. On the top of the shaft is mounted an 8-pole, 30-KW., 125-volt General Electric exciter. The collector rings for the alternator field are at the top of the shaft.

Fig. 3 shows one of the generating units at close range, with the governor at the right. Each machine has its own governor, furnished by the I. P. Morris Company, of Philadelphia. A strong point in the design of the alternators is the provision for ventilation. The circumference of the armature frame is liberally equipped with air ducts, from the base to the top of the machine.

Every point in the generator room is accessible to the crane service, including parts of the basement through floor covers and openings. In the southeast corner of the generator room is mounted a General Electric

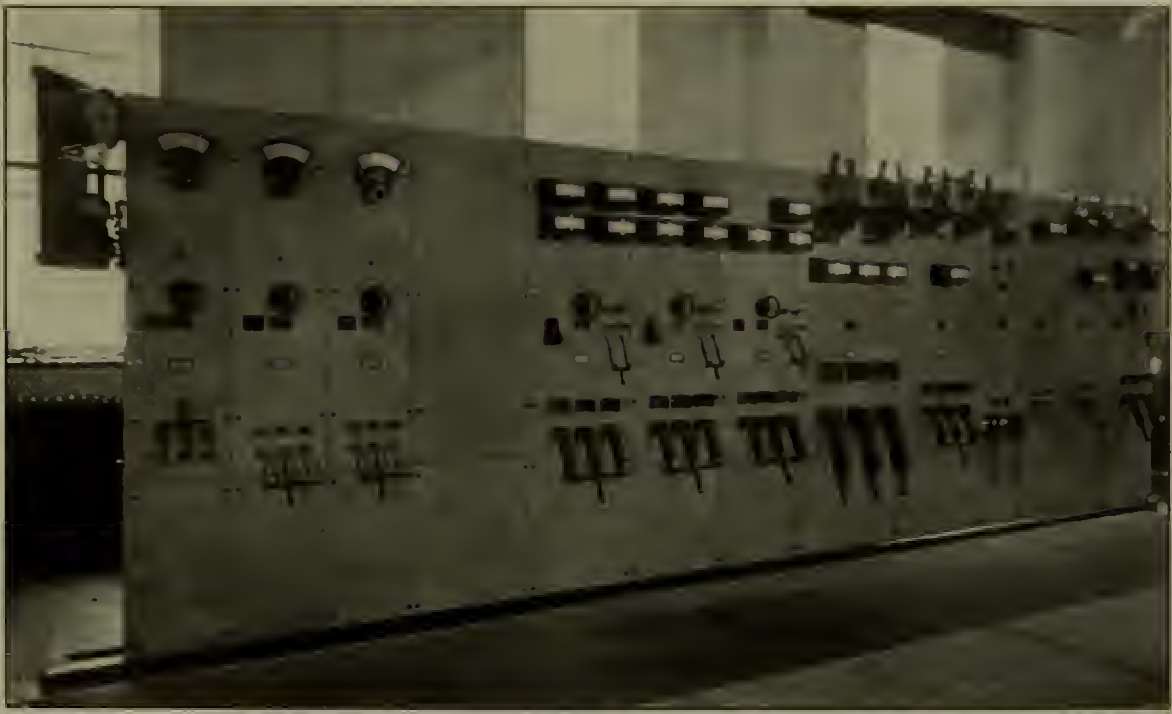


FIG. 4.—THE SWITCHBOARD AT THE PROCTOR POWER HOUSE. SO EXTENSIVE IS THE ELECTRIC EQUIPMENT IN THE COMPANY'S PLANT THAT THIRTEEN PANELS, ONE FOR FUTURE USE, ARE REQUIRED FOR THE INSTRUMENTS AND SWITCHES

FIG. 5.—A 250-H. P. INDUCTION MOTOR DRIVING A LINE SHAFT IN THE MARBLE-SAWING MILL

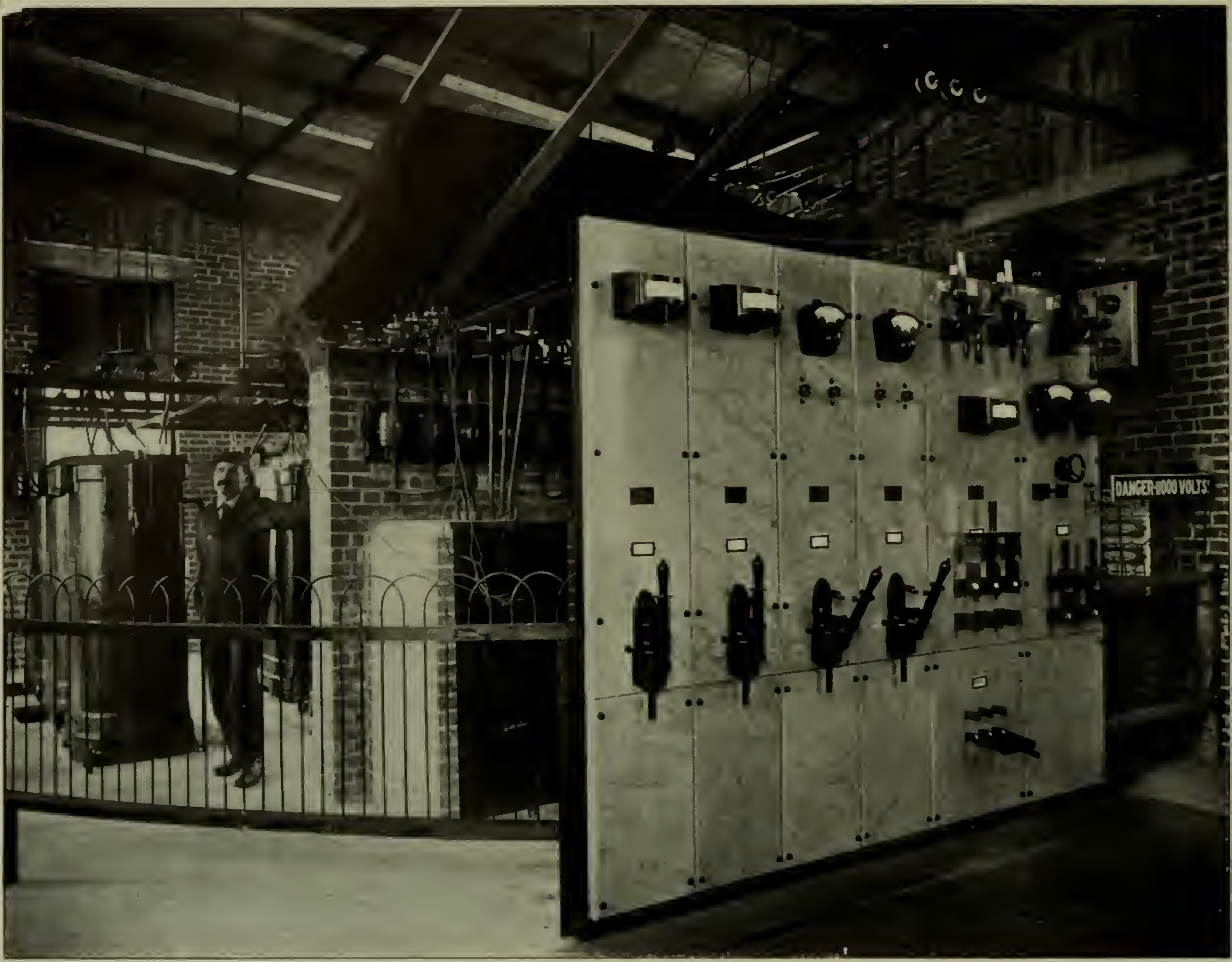


FIG. 6.—INTERIOR OF THE SUB-STATION AT THE WEST RUTLAND PLANT OF THE VERMONT MARBLE COMPANY. CURRENT IS TRANSMITTED FROM THE PROCTOR POWER PLANT AT 10,000 VOLTS AND STEPPED DOWN TO 3300 VOLTS AND 460 VOLTS

motor-generator set for supplying direct current at 250 volts to certain motors in the mills. The set consists of a 6-pole, 150-H. P., 440-volt, 3-phase induction motor direct coupled to a 4-pole, 100-KW., 250-volt direct-current generator.

A peculiar feature of the situation at Proctor is the close identification of the Vermont Marble Company with all town affairs. The community is industrially a unit, in much the same manner as the towns of Hopedale, Mass., controlled by the Draper cotton manufacturing machinery interests, and Peacedale, R. I. It is outside the range of this article to discuss the admirable relations between the employer and the employee which exist in Proctor; but in the control which the company exercises over the town the electric lighting is included, and current for this purpose is drawn from the company's power station. The switchboard, therefore is laid out to handle the municipal lighting load as well as the company's industrial power and lighting demand.

Fig. 4 shows the switchboard at the Proctor power station. It consists of thirteen blue Vermont marble panels, 90 inches high and 25 feet long. From left to right these panesl are devoted to the following services:—

Panels 1, 2 and 3. Exciter control, with triple pole, single-throw switches, potential plugs, rheostat handles and 400-ampere Thomson static ammeters.

Panel 4. Blank, for future exciter of fourth unit.

Panels 5, 6 and 7. Generator control, with triple-pole, single-throw switches, potential plugs, field switches, rheostats, one Thomson 2000 indicating edgewise ammeter per panel, one Thomson 1600-KW. edgewise indicating wattmeter per panel, one Thomson 700 alternating-current voltmeter and one Thomson 100 ammeter per panel

Panel 8. Controls primaries of high-potential line transformers. Three 2600-ampere, 480-volt separate single-pole knife switches, three 5000 Thomson ammeters, edgewise type, two automatic circuit breakers.

Panel 9. Motor control, mill circuits, alternating current, three-phase. Triple-pole, single-throw switch, 480 volts, 2000-ampere Thomson ammeter.

Panel 10. Arc-light tub transformer, 480-volt primary side, circuit plugs and 8-ampere ammeter.

Panel 11. Incandescent lighting control, 480 volts, multiple three-phase distribution, triple pole, single-throw switch, 200 Thomson ammeter.

Panel 12. Induction motor of motor-generator set control, 480 volts, 400 ammeter and two circuit breakers.

Panel 13. Generator control motor-generator set, 250 volts. Positive and negative single-pole switches, field switch, 600 ammeter and 350 voltmeter.

The largest quarries of the Vermont Marble Company are located at West Rutland. A three-phase, 11,000-volt transmission line, 5½ miles long, of No. 1 copper, runs between Proctor and West Rutland, via Albertson. A sub-station is located at Albertson and another at West Rutland.

In the basement of the Proctor plant are installed three 500-KW. water and oil-cooled transformers connected in delta on both primary and secondary sides. These raise the voltage from 480 to 11,000 volts. The distribution circuits from the Proctor power house are carried out on overhead lines, the transmission poles being 35 feet long, of cedar, and spaced 100 feet apart.

The plant operates continuously, with the exception of the hours between 12.30 A. M. and 5.30 P. M. on Sundays. At one side of the generator room is a 50-drop telephone switchboard in a booth. From 6 P. M. to 6 A. M. the local night service of the New England Telephone & Telegraph Company is handled by the power station attendants.

The traveling crane in the yards at Proctor, the local quarry and machine shop motors are supplied with direct-current, 250-volt power.

In the basement of the Proctor power house is a Morris centrifugal pump for supplying pressure to the governors at about 18 pounds per square inch, direct-connected to a 4-pole, 5-H. P., 110-volt motor. There is also a Gould triplex oil pump belted to a 480-volt, 1-H. P. induction motor. The cellar drainage is handled by a centrifugal pump driven by a 7½-H. P., 6-pole, 480-volt induction motor. The convenience of the small motor in driving these hydraulic auxiliaries was thoroughly taken advantage of at the Proctor plant.

The load at Proctor can be operated upon one wheel at times of low water, but in order to handle the load at West Rutland, a supplementary steam plant is in service there.

The equipment of the West Rutland sub-station consists of three 150-KW., 10,000-3300-volt transformers, for an old motor equipment which is in service, three 150-KW., 10,000-460-volt transformers for new motors, and a 250-KW., 250-volt motor-generator set. The motors range in size from 75 H. P. to less. A 50-light tub transformer for street service is also in use at this station. Fig. 6 is an interior view of the West Rutland sub-station, showing the 10,000-volt switchboard and transformers. A special shield was installed between the horizontal high-tension bus-bars and the roof, to prevent the occurrence of fire.

At the Albertson sub-station are installed three 100-KW., water-cooled transformers, stepping down from 10,000 to 480 volts. The motor equipment at Albertson includes a 75-H. P. General Electric motor, and a 75-H. P., 440-volt Bullock motor, and a 100-H. P. General Electric motor belted to a 75-KW., 250-volt generator for lighting and crane service.

All the machinery in the mills is group-driven. Fig. 5 shows a 250-H. P. induction motor in the marble-sawing mill at Proctor. The machinery includes gang saws, rubber beds, lathes and planers, polishers, gritters, pumps, air compressors, exhaust fans, cranes and hoists. In the quarries, channelers and also an experimental electric drill are driven by electric motors.

Producer Gas Power in Central Station Work

The New Plant of the Citizens' Electric Company, of Keene, N. H.

By J. R BIBBINS

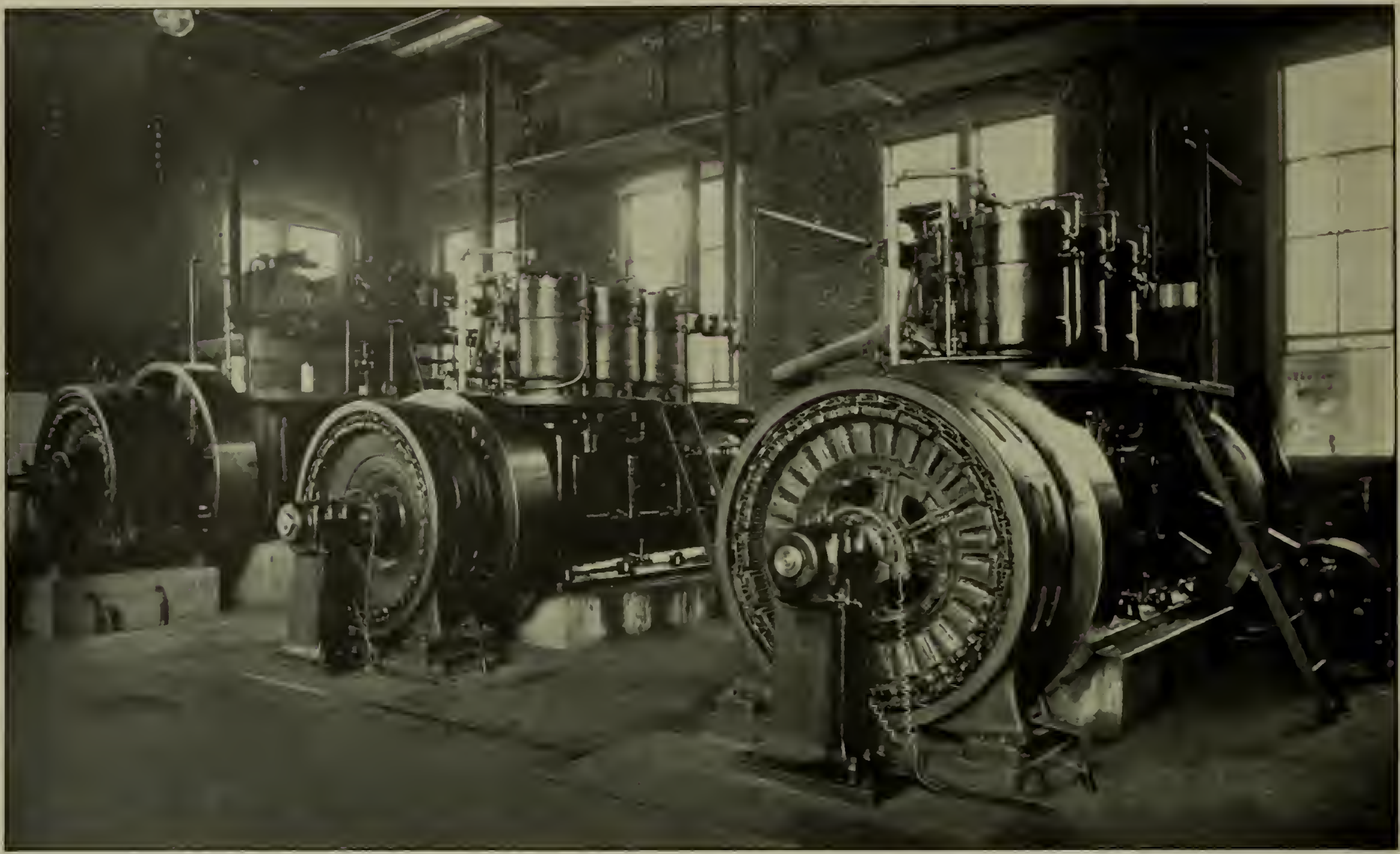
TO power users in localities where fuel may be readily and cheaply secured, the question of most economical plant equipment is obviously not so important as in those localities where the proper size of fuel is not only expensive, but also frequently difficult to obtain in emergencies.

A large central station delivering 24-hour power must not only consider the cost of production, but also the question of obtaining and storing sufficient fuel to carry them over a period of possible strikes, railway accidents, or other contingencies. But in small stations, such as form probably 80 per cent. of the central stations of this country, covering towns and cities up to 10,000 inhabitants, the question of power costs is one of relatively greater importance than storage of fuel, for the reason that the small amount actually used would not occasion any serious inroads upon the supply of fuel available in the immediate neighbourhood.

In both of these cases producer gas comes to the rescue, and it is the purpose of this article to show by means of a specific example how the producer gas system may be applied effectively to the continuous production of cheap power in communities using electricity for lighting and manufacturing purposes. The system at Keene, N. H., which this article describes, is fairly typical of the great majority of New England towns in which small anthracite coal is the most available fuel for power purposes. Few towns of pretentious size have failed to provide themselves with electric lighting service, with the result that many small plants are in operation, usually with low efficiency, due to poor load factor or antiquated apparatus. Because of the high price of coal, the cost of power is high, and so also, as necessarily follows, are the power rates to customers.

One of the principal reasons for the adoption of gas power at the new plant at Keene was to enable the new company to curtail their power costs as much as possible. This was a necessity, for the company was, in fact, organized under strong competition with the long established Keene Gas & Electric Company, formerly holding exclusive service franchise in the city. Owing to the sustained price of electricity and the old company's refusal to deliver electric light in some localities where gas mains were already laid, and similar policies tending to alienate the support of new customers, the Citizens' Company came into existence with considerable private business in addition to a five-year contract to light the city.

The company's articles of incorporation were filed on May 5, 1905. Work was started on the lines July



IN THE GAS-POWER PLANT OF THE CITIZENS' ELECTRIC COMPANY, OF KEENE, N. H., THREE WESTINGHOUSE UNITS, AGGREGATING ABOUT 400 H. P., SUPPLY CURRENT FOR LIGHTING AND POWER

1, the public lighting contract was taken over November 1, and private lighting commenced on January 1, 1906. Thus in a period of four months the plant was far enough completed for the commencement of regular service, and in six months both station and lines were entirely completed.

The original rates for electric service in Keene were as follows:—Lighting, 16 cents net; power, 10 to 4½ cents. Previous to the starting of the Citizens Company service, however, there were no published rates for power. The new company's rates are based on a sliding scale, tending to encourage large customers: Lighting, 10.8 to 7.2 cents per kilowatt-hour net, with a minimum charge of 75 cents per month; power 5 cents down to 2½ cents per kilowatt-hour, minimum charge of 75 cents per E. H. P. per month. To meet these new rates the old company reduced to the same gross rates, and offered, in addition, a 10 per cent. greater discount for prompt cash payment. City arcs (6.6 amperes) formerly cost the city $100 per arc for sundown-sunrise service; now the cost is $82.50 per arc (6.9 amperes). Series incandescents, formerly $29, now cost $21 per year. Thus the Citizens' Company has effected a reduction in the price of electricity to both municipal and private consumers of about one-third.

EXTERIOR OF THE GAS-POWER PLANT OF THE CITIZENS' ELECTRIC COMPANY. THE ABSENCE OF ANY SMOKESTACK IS A CONSPICUOUS FEATURE

It is evident from the above that in order to effectively reduce power rates by so large a margin, and particularly to offer a power rate as low at 2½ cents per kilowatt-hour, the efficiency of the generating station must be of a very high order. The cost of fuel delivered at Keene is from $4.25 to $4.50 per ton, so that every possible economy consistent with ultimate reduction of power costs would have to be practiced.

The choice of the gas-power system as a means of securing this result was determined upon after considerable inquiry among the various builders of power station apparatus. A central station has resulted which, although of comparatively small size, is operating with exceptional economy, and has fully met the expectations of the officials of the company as regards general reliability and excellence of results.

During the early part of the year, when the load factor of the station was but 14½ per cent. for 24-hour service, the average coal consumed by the producers was 2¼ pounds per kilowatt-hour, or less than 1½ pounds per B. H. P.-hour, which corresponds to a plant efficiency of 14.35 per cent. from coal pile to engine shaft, or 12.1 per cent. from coal pile to bus-bar. Moreover, the total operating cost at this extremely low load factor, including fuel, labour, supplies and repairs, is as low as 1.7 cents per kilowatt-hour with an average output of only about one-seventh of the plant capacity. At this rate, an operating cost of about 1 cent per kilowatt-hour will obtain when the station load factor has reached about 25 per cent.

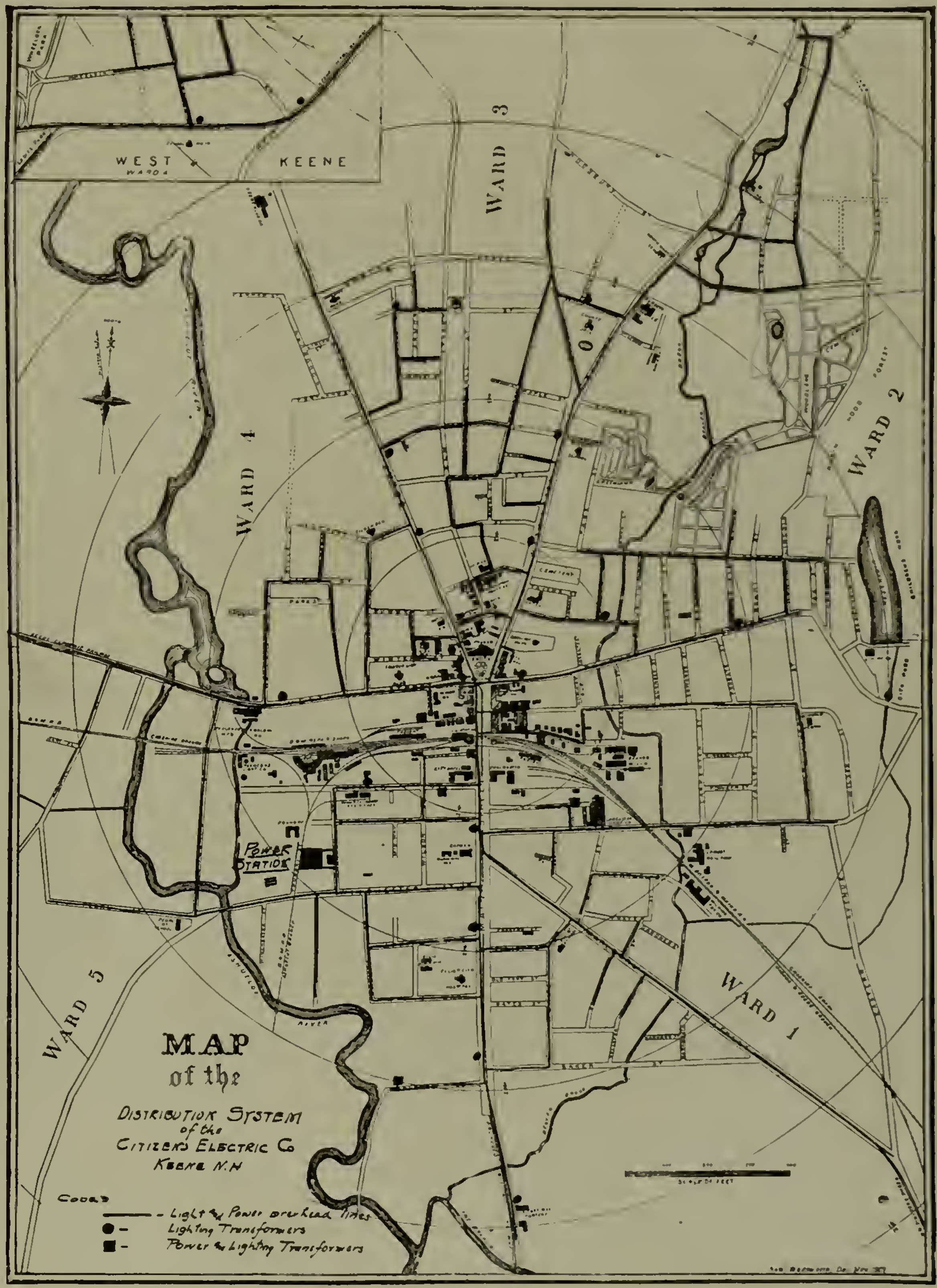
SYSTEM

From the accompanying map may be obtained a clear idea of the district covered by the distribution system. It will be noted that the principal business section is located well within the quarter-mile circle, which fact minimizes the copper required to handle the business load. Arc and residence transmission lines, however, branch in all directions, the former run in as single-phase and the latter as three-phase, both with grouped transformers. Arc, incandescent, and power circuits are operated from the same station bus, although an auxiliary bus is provided at the station for emergencies.

POWER STATION

In the general view of the power station the considerable difference between a design adapted for gas and the conventional design adapted to steam power will be at once recognized. In this building the engine room occupies fully two-thirds of the floor area and the producer room one-third. Observe that no chimney is used, with the exception of a small vent pipe above the producers. The coal storage bin shown in the rear of the power station provides a storage capacity of 250 tons, sufficient to run the plant at the present rate of fuel consumption for over seven months, which obviously avoids any danger of fuel shortage from almost any cause.

In the interior is a more or less conventional arrangement of gas engine machinery. Three units, aggregating about 400 H. P., of the



Westinghouse vertical, direct-connected type, are installed, all controlled from the alternating-current switchboard shown in another view in the manner customary in modern steam plants. Paralleling the generators and adjusting the load is accomplished with great facility, as the governors may be quickly adjusted by hand while running.

The engines are started by compressed air, as usual with Westinghouse engines. For this purpose a number of storage tanks are kept continually charged up to a pressure of 150 pounds per square inch, and immediately refilled after each start, whether the pressure is low or not. As a usual thing, a few turns of the engine is sufficient to enable it to catch its ignition. Both motor and gas-engine-driven air compressors are available.

Each engine receives its gas supply from an independent riser to the main, in which is interposed an automatic diaphragm regulator which reduces the main pressure to approximately atmosphere at the engine. Gate valves are located at the gas main in each engine branch, very much as in an ordinary steam plant. At the engine are two more regulating valves with graduated indices, which serve as a guide in proportioning, according to the quality of the gas, the actual mixture of air and gas that is sent as mixture to the governing valve and thence to the cylinders. This adjustment renders it a simple matter to accommodate widely varying qualities of gas should it become necessary.

The exhausts extend out through the building wall and by long sweep elbows into a brick tunnel, 24 inches square, leading to an exhaust well filled with broken rock, and

A PART OF THE GAS-PRODUCER PLANT OF THE CITIZENS' ELECTRIC COMPANY. TWO 250-H. P. SETS ARE INSTALLED, ONE BEING SHOWN HERE. ON THE RIGHT IS THE PRODUCER SHELL, WITH THE COAL-CHARGING HOPPER ON TOP. ON THE LEFT IS THE SCRUBBER

having a capacity of 500 cubic feet. This well so effectively breaks up the force of the successive exhausts as to completely muffle the reports with the result that no objections have arisen from this cause, although several residences are located within a few hundred feet.

Cooling water is supplied to the cylinder jackets, heads and exhaust valves from a 600-gallon elevated tank, which is, in turn, filled by a motor-driven pump, the motor being controlled by an automatic float in the tank, arranged to maintain an approximately constant level.

Each unit drives its own exciter, although the excitation may be interchanged when desirable. The familiar "make-and-break" igniter system is employed. Not one, but four independent sources of ignition current are available, namely, primary batteries, storage batteries, exciters and a small 1-KW. motor-generator set which is normally used for this work. All igniter wiring is run in loricated iron conduit right up to the engine cylinders.

Lubrication is largely automatic, as the engines are single-acting and self-contained. The crank case being filled with oil to about the level of the shaft, at each revolution the cranks splash sufficient quantities of oil over the internal rubbing surfaces as to make it unnecessary to supply further lubrication, with the exception of the main bearings. These, however, require only infrequent replenishing, the oil used for this purpose draining directly into the crank case, and thus serving to replenish the loss by evaporation.

THE PRODUCER PLANT

A most interesting feature of the station is the producer plant, part of which is shown in the accompanying illustration. Here is generated the power gas for supplying the engine equipment above described. This part of the station consists of two 250-H. P. producer sets of the Westinghouse automatic water-sealed type. One complete unit is shown. On the right is the producer shell, with the coal-charging hopper on top and the ash pit beneath. On the left is a double-compartment scrubber containing, on one side, coke continually wetted by water sprays, and on the other side a drying section containing excelsior. The scrubbed and dried gas leaves by the upper outlet shown.

Between producer and scrubber is located a three-way valve providing communication between producer and purge stack when the new producer fire is being started. This valve at the same time shuts off the scrubber so as to prevent any back flow from other producers in operation. At one side is a small vertical boiler (not shown), used for supplying steam to blow the producer. As the gas-making process is practically a continuous one, this small boiler is enabled to work at a fairly constant rate.

One of the essential points of the Westinghouse producer is the arrangement for the automatic production of gas in exactly the quantity required by the engines. Unlike the intermittent process, this obviates entirely the use of a gas holder, small or large, and, consequently, the increased investment in a holder and ground space and the necessity for warming the holder during winter, which is by no means a small item.

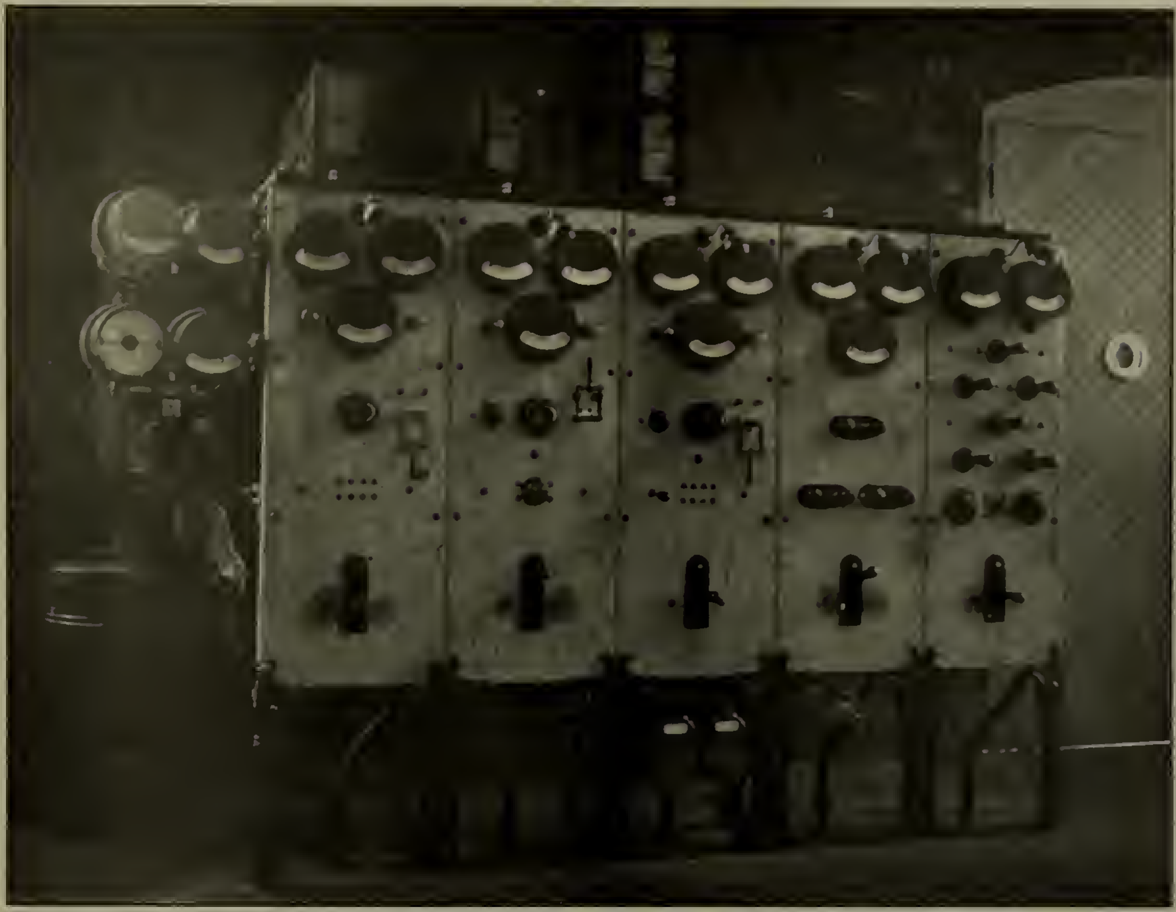
The governor which controls the steam blast to the producer is simple, consisting of a diaphragm regulator actuated by gas pressure leaving the scrubbers. The resulting movements of the diaphragm are transmitted to a throttle valve in the steam line from the boiler. Thus the steam blast is varied according to the demand for gas by the engines. The mechanism is not sluggish, but responds instantly to any change in rate of gas delivery. Moreover, the ratio of steam to air supplied to the producer in the form of blast is likewise regulated to a nicety, as is necessary for the production of good gas, all this regulation being accomplished automatically and requiring practically no attention.

Another good feature of the producer plant is that not a pound of coal is handled by manual labour from the time the fuel is delivered to the bins until about 15 per cent. of it is removed in the form of ash from ash pits. A small bucket conveyor lifts the coal from the bins to small overhead hoppers, from which it is delivered by gravity to the producer hoppers as required. On this account, the amount of manual labour required to run the producer plant is astonishingly small. The entire power plant at full load consumes a little over 500 pounds per hour, or 250 pounds per hour per producer. As each producer hopper holds about 275 pounds, this means that the producer needs to be charged hardly once an hour even at full load. As a matter of fact, the average time between charges is even longer. Ashes are removed but once in twenty-four hours. This is owing to the large volume of the fuel bed, which allows an accumulation of ash without detrimental consequences. The remaining duties of the producer attendant consist in easing down the fuel bed from the producer walls, which requires, perhaps, five minutes' work two or three times during a watch.

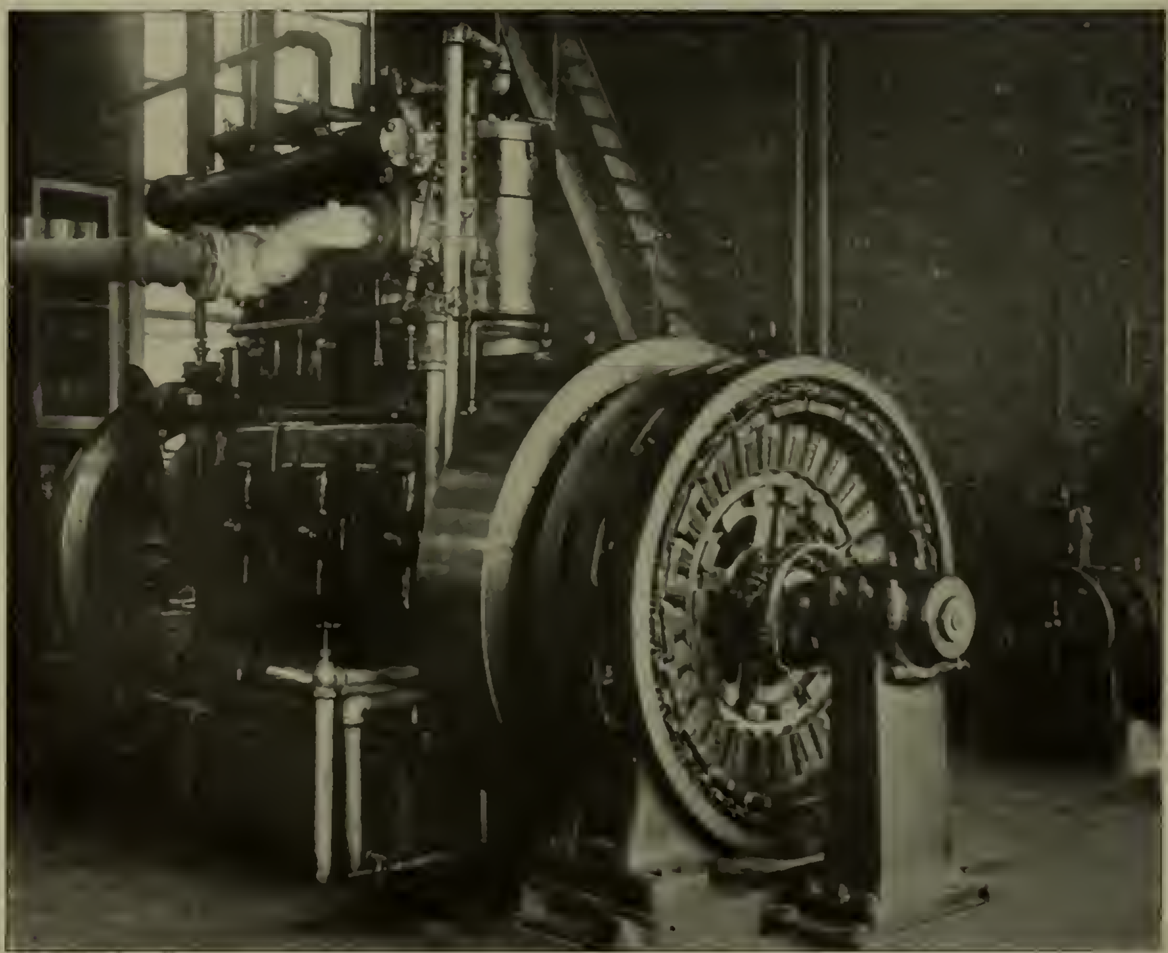
Unlike the scrubbers used in the cleaning of bituminous gas, these scrubbers need almost no attention for months at a time. The coke section is indestructible. The excelsior section requires cleaning once or twice a year, although recently the excelsior was examined in the first scrubber put into operation and was found, after nine months' continuous service, to be cleaner than the new excelsior which had been obtained for renewal purposes, and was, consequently, left in place.

As regards the operating staff, it is the policy of the operating company to provide at least two men in the plant at one time, not only for increased security against accident, but also from the standpoint of the men's personal safety. Thus, one man has charge of the engine room during each 12-hour shift and one man the producer room,—500 H. P. of power machinery per man.

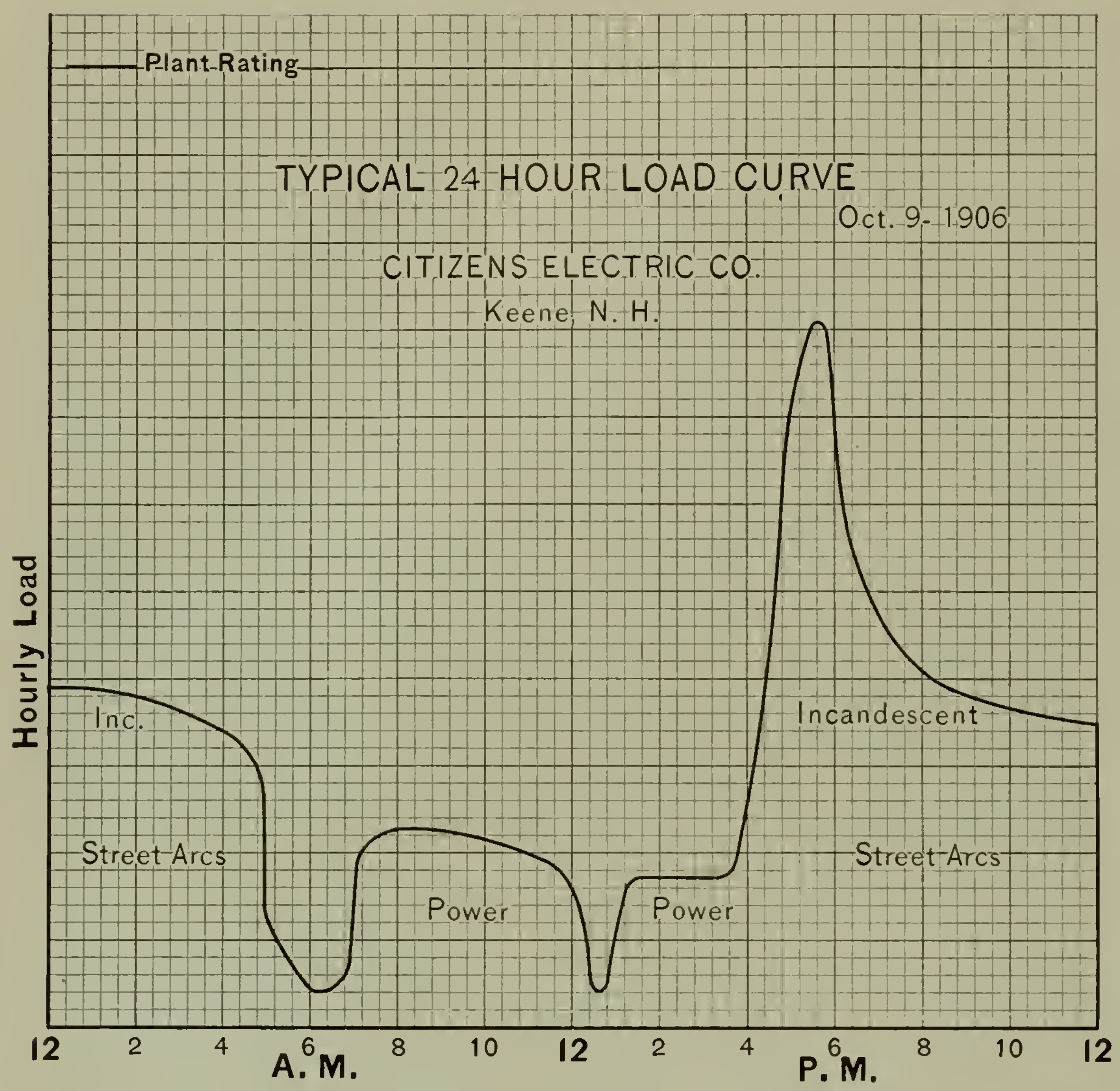
But the small amount of work



THE SWITCHBOARD IN THE CITIZENS' ELECTRIC COMPANY'S PLANT



EXHAUST SIDE OF ONE OF THE GAS-ENGINE UNITS



A TYPICAL LOAD CURVE OF THE GAS-POWER PLANT OF THE CITIZENS' ELECTRIC COMPANY

actually necessary is evident from the fact that on several occasions, when the necessity arose, one man was left in charge of the entire plant and operated it successfully, taking care of both producer and engine equipments. Moreover, this was accomplished not only when the plant was running normally, but at a time when it was necessary to start up another unit. This he succeeded in doing in less than a minute of time, the producer meanwhile taking care of itself by means of the automatic regulator.

The fuel rate of the station operating a short time ago on a load factor of only 14 per cent. (average load on engines 40 per cent.) was $2\frac{1}{4}$ pounds in the producers per kilowatt-hour generated, using a medium grade of pea anthracite. At present, with a load factor of 23 per cent., the fuel ratio is from $1\frac{3}{4}$ to 2 pounds per kilowatt-hour at the producers. Were it possible to load this station up to, say two-thirds of its rated capacity, the relative coal consumption would be to the order of 1.85 pounds per kilowatt-hour, or 1.2 pounds per B. H. P.-hour, and the operating cost about 0.6 cent per kilowatt-hour.

The producer-gas-engine plant, as a whole, is thus an extremely simple mechanism for the efficient conversion of heat of coal into work, and a distinct point in its favour is the fact that it is much less affected by variations of load than a steam plant, particularly if a sufficient number of generating units are available for "fitting into" the station load curves. The producer especially retains its high efficiency on low output, as compared with a steam boiler, which is evidenced by the fact that a producer of this size will stand an entire day with the addition of a few buckets of coal to replenish the fuel bed. This means that the standby losses of the producer plant are many times less than those of a steam boiler plant, especially when the latter must be kept banked on the line and up to full pressure, anticipating sudden increase in load that may occur at any time. In one of the largest and best-regulated boiler plants in an Eastern city it has been found that under these conditions the standby fuel is fully 30 per cent. of the full-load running fuel.

In conclusion, from this small plant it is not difficult for a practical man to observe the true state of affairs in regard to gas vs. steam operation. The prevailing incredulity of power plant men and their bias against gas may be truthfully set down to a lack of direct experience. The running troubles of a steam plant have been so long encountered that they are fixed in the operator's mind as nothing extraordinary and quite to be expected. On the other hand, however, the slightest troubles in gas working have been so grossly magnified by steam enthusiasts as to engender in the mind of the power plant manager (who in reality obtains his impressions from his operators) an adverse opinion of unreliability which is not according to fact.

But the gas-power system has, nevertheless, come to stay, and a practical man has only to observe for himself the actual running of a plant like this to appreciate at its true value this extremely simple system. He has avoided high pressures, superheaters, economizers, feedwater heaters, condensers, mechanical draught, dry air pumps, stokers, and the like, all auxiliaries of rather rapid rate of depreciation and requiring much attention, as well as an appreciable steam consumption. This should be considered a distinct advantage of gas in the production of power.

The Inductor Alternator

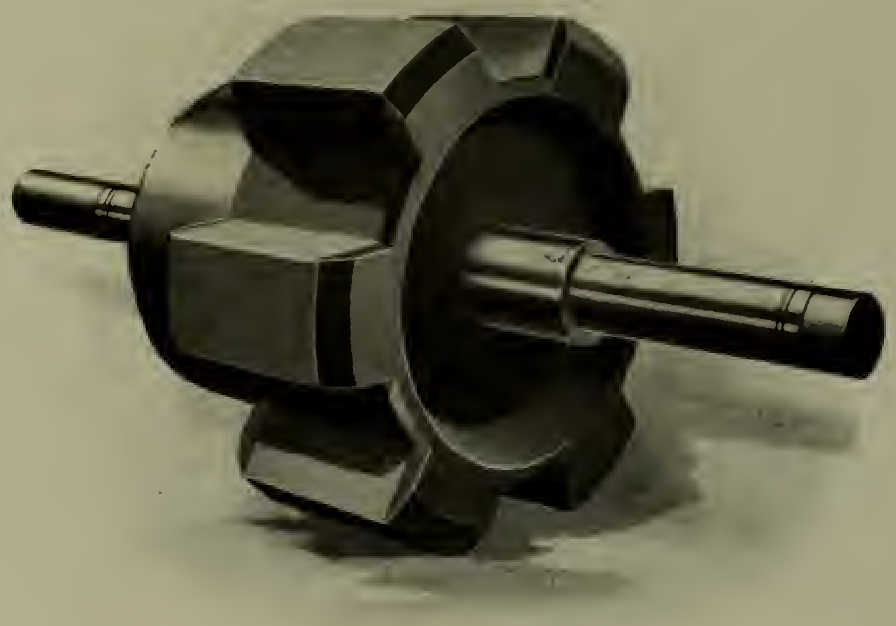
By A. E BUCHENBERG

THE commercial success of the inductor type of alternating-current generators is due primarily to their mechanical simplicity, substantial construction, and high operating efficiency. The distinguishing mechanical features, as compared to the revolving-armature or revolving-field type of alternator, are the absence of commutator and collector rings, and the elimination of moving wire of every description. The only parts of the machines subjected to wear are the bearing sleeves.

The inductor type of alternator as usually constructed consists of a stationary laminated iron armature and a rotating inductor with projecting poles, the tips of which are laminated. The direction of the magnetic lines of force is in a plane through the axis of the shaft, and the magnetic circuit is completed through the solid metal of the poles and body of the rotor and the structure supporting the armature iron, as shown in Fig. 3. The polarity of all poles of the inductor is the same, and, therefore, the flux through the armature coils is always in the same direction.

The inductor pole pieces sweeping past the armature coils force an intermittent flux through the armature iron enclosed by them; this flux varies from zero to a maximum value and back again to zero. The periodic magnetization of the armature iron is, therefore, carried through but one-half the complete cycle of magnetization, and for the same maximum flux density, length of path, and volume of iron, the hysteresis loss will be but one-half that of the other types of machines with alternate north and south field poles.

From the above it is obvious that for maximum effective voltage, but one side of any armature coil can be in an active field, while the other side must be in an inactive, or zero, field; or, in other words, one side of the coil must lie in the space between the inductor pole projections. Therefore, with a given flux and armature winding, the terminal voltages of an inductor alternator will be only one-half as great as that of the other type of machine; or conversely, with a fixed armature winding the total magnetic flux must be doubled to obtain the same electromotive force. This condition is partly realized by the fact that on account of the extremely short magnetic path, and the comparatively small amount of iron, very



FIGS. 1 AND 2.—INDUCTOR AND ARMATURE OF AN INDUCTOR ALTERNATOR BUILT BY THE WARREN ELECTRIC MANUFACTURING COMPANY, SANDUSKY, OHIO.

high flux densities can be used in the armature iron of inductor alternators without core losses of a prohibitive amount.

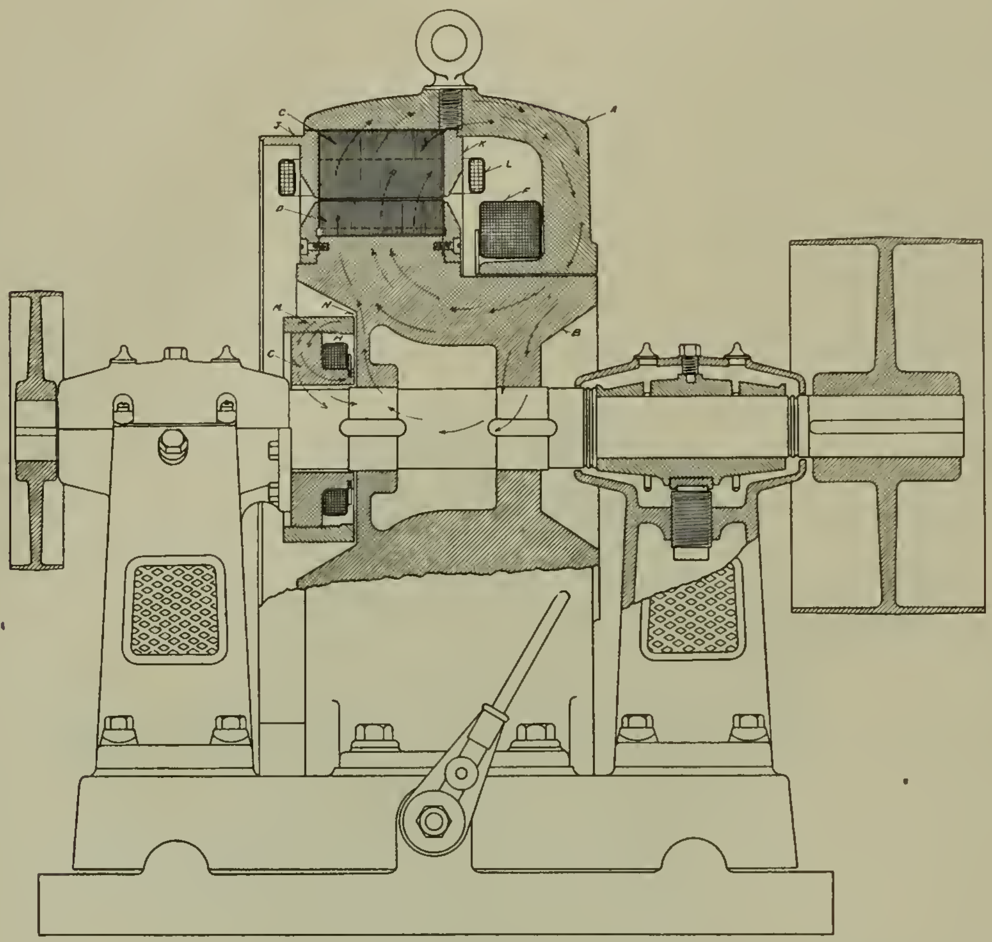


FIG. 3.—DIAGRAM SHOWING THE PATH OF THE MAGNETIC LINES OF FORCE IN THE WARREN INDUCTOR ALTERNATOR

While only one-half the total armature conductors are available for generating the machine electromotive force, the idle half also must carry the armature current, and their self induction will affect the voltage regulation of the machine. At the same time their ohmic resistance will contribute to the copper losses of the armature. In addition to this they will not be passing through a strictly zero magnetic field, but will be cutting the leakage flux emanating from the poles and body of the inductor.

The flow of current through the armature winding in the slots sets up a magnetic field enclosing these conductors. This field varies directly with the armature current, and is inversely proportional to the reluctance of its flux path. The variation of this flux with the cyclic change of armature current induces an electromotive force of self induction or counter electromotive force in the armature conductors. The armature current and the reluctance of the flux path being fixed, this electromotive force of self-induction will vary as the square of the conductors per slot.

The flux set up by the armature current as explained above flows in a double path, a part directly across the slot opening and the other part around the slot. The reluctance of the path across the slot is directly proportional to the width and inversely proportional to the depth; or in other words, the flux is smaller for a wide shallow slot than for a narrow deep one. For the above reasons the ratio of depth to width of inductor alternator armature slots is always small, and rarely exceeds 1.75.

The flux flowing entirely around the slot is inversely proportional to the reluctance of this path, which is made large by the use of high magnetic densities in the armature teeth. The use of wide, shallow slots, in conjunction with high armature-tooth and air-gap densities, keeps the counter electromotive force of self-induction to a very low limit, and, to a great extent, offset the disadvantage stated above.

The action of the leakage flux from the sides and body of the inductor to the surface of the armature induces electromotive forces in the armature windings, opposing those generated in the active half of the coils. The use of a small armature air gap, and the cutting away of all metal between the rotor poles, reduces this action to a minimum.

Still another factor affecting the voltage regulation of an alternator is the armature reaction under inductive load operating conditions. With unity power factor the action of the armature current is only to distort the field flux somewhat, but with lagging currents the component in quadrature with the electromotive force tends to set up a flux in direct opposition to that of the field. In the inductor type of machine this action also is taken care of by working the armature iron well above the "knee" of the saturation curve, and the use of high armature air-gap densities, as before stated.

There is no difficulty whatever in designing and building alternators of the inductor type to meet ordinary conditions of regulation, efficiency, and heating, for both inductive and

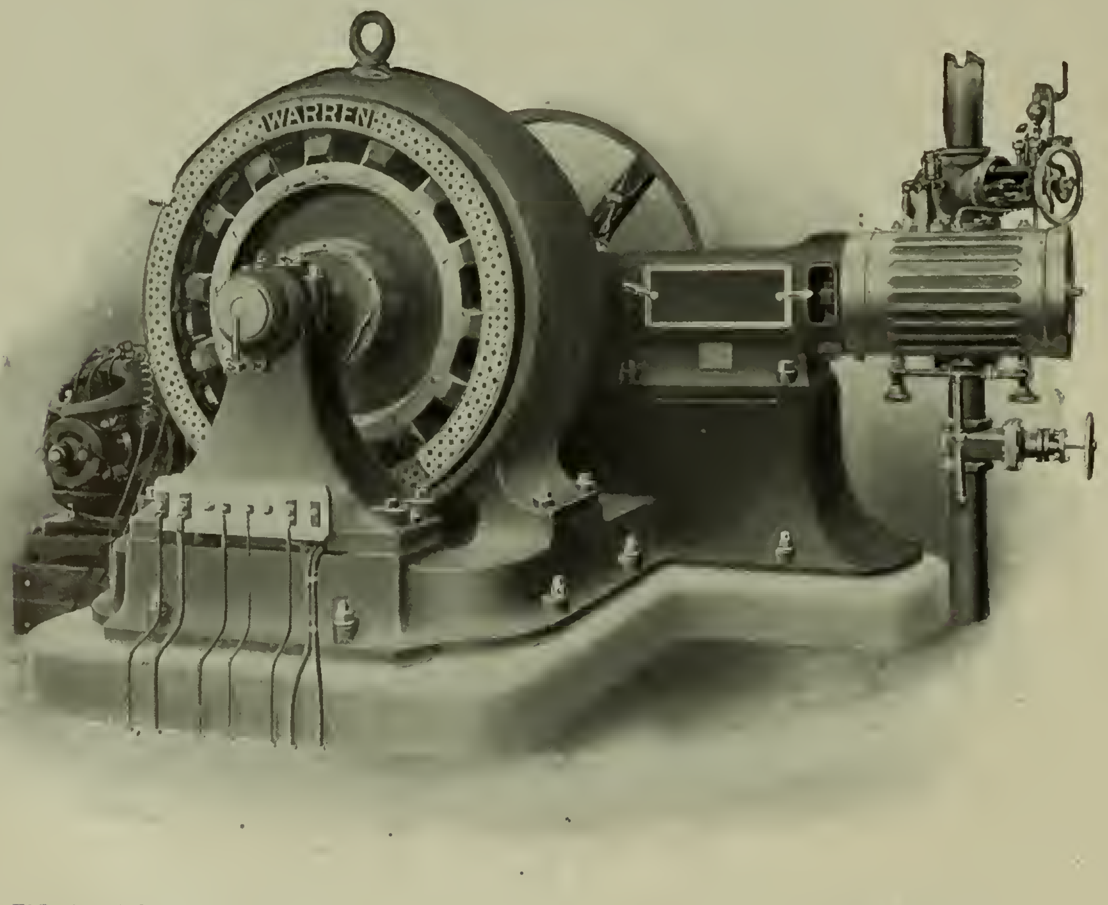


FIG. 4.—A WARREN INDUCTOR ALTERNATOR DIRECT CONNECTED TO A STEAM ENGINE

FIG. 6.—INDUCTOR OF A 2000-KW. INDUCTOR ALTERNATOR BUILT BY THE STANLEY-G. I. ELECTRIC MANUFACTURING COMPANY, OF PITTSFIELD, MASS.

non-inductive loads. Where operating conditions and machine performance guarantees call for close voltage regulation on low power factor loads, the machine becomes somewhat heavy as compared with other types having the same characteristics.

The apparent requirements for excessive weight of iron to afford the necessary flux path area are partly compensated for by the fact that the inductor type of machine requires no additional cast-iron or steel structure to support the armature iron, and that all the metal used in the construction of the machine is useful in carrying active flux. The use of high magnetic densities as stated above materially reduces the weight of the armature laminations.

The entire construction lends itself admirably to the best utilization of the maximum safe strength of the metal in the rotating structure, allowing the use of high peripheral speeds, which in many cases is a distinct advantage in economical design.

As the air gaps used are small and the length of flux path through the saturated portions of the magnetic circuit very short, the leakage is kept well within practical limits and all other parts of the machine carrying active flux can be worked at a moderately high density with but a small expenditure of exciting energy.

The concentrated type of winding in open slots is invariably used for armature coils, and lends itself admirably to the electrical and mechanical requirements of this type of alternator. Concentrated winding permits of maximum armature copper and insulation area with a minimum loss of useful armature surface. From the standpoint of the station man this type of winding is convenient in the case of repairs, as an armature coil can be removed and another substituted without disturbing a number of other coils. In most machines of this type the armature coils can be removed without in any way dismantling the machine, by simply dropping a coil between two adjacent inductor poles and then pulling it out endwise.

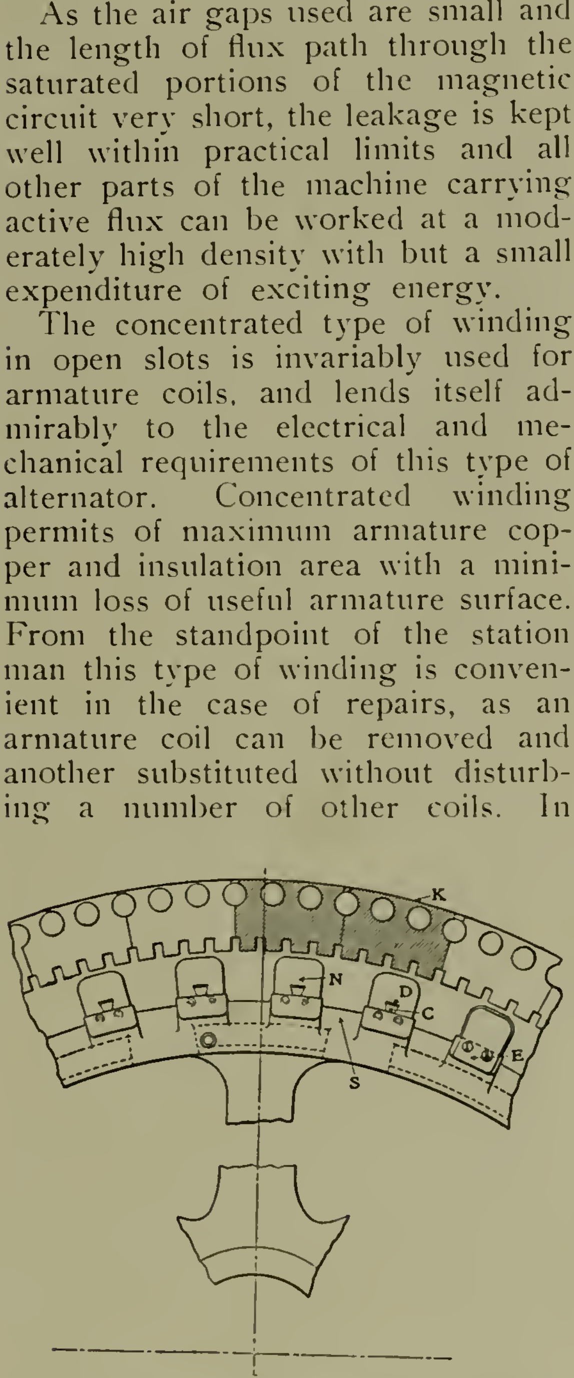


FIG. 5.—SECTION OF A STANLEY-G. I. INDUCTOR ALTERNATOR

As a practical example of modern construction of inductor alternators we have selected the machine built by the Warren Electric Manufacturing Company, of Sandusky, Ohio. In Fig. 3 *A* is the frame of the machine which performs the triple functions of carrying the active magnetic flux, supporting the armature iron *C*, and affording a convenient and effective support for the main field coil *F*.

The annular projection of the frame casting forming the field coil support also performs the second function of increasing the air-gap area at the smooth end of the rotor, thus decreasing the flux density and allowing a reasonable clearance with a moderate magnetomotive force. While the armature air gap varies with different machines, the above clearance is always one-sixteenth of an inch, and is ample for any wear of the bearings. The armature laminations *C* are assembled inside the smooth bore of the frame on the cast-iron armature ring *K*, which is supported by a shoulder on the frame casting, as shown.

The armature laminations are punched from very soft double-an-

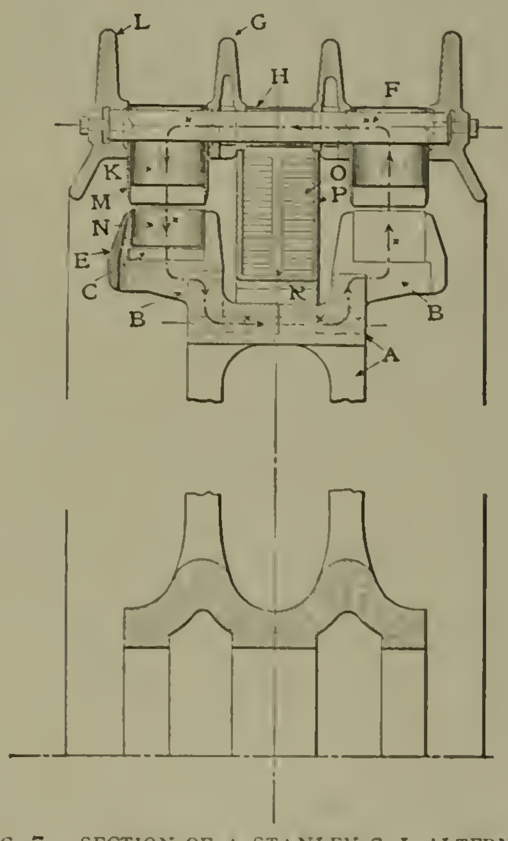


FIG. 7.—SECTION OF A STANLEY-G. I. ALTERNATOR, SHOWING THE MAGNETIC PATH

nealed electrical steel, and after being notched are given a thin coating of insulating varnish in order to reduce the eddy current losses to a minimum. After being properly compressed under heavy pressure they are held in place by the outside cast-iron armature ring *J*, an extension of which forms a portion of the armature coil shield. The depth of armature stampings behind the slots is such as to confine all changes and swinging of flux to them, so that there are no hysteretic or eddy current losses in the solid portions of the frame and armature structure. Fig. 2 will possibly give a clearer idea of the frame construction.

The rotor or inductor *B* is smooth on one end with projecting poles on the other or open end of the machine. To avoid the eddy currents set up by the sweeping of the slot openings across the pole faces, the pole tips *D* are laminated. These laminations are dovetailed into the poles and supported by clamping plates as shown in Fig. 1 and Fig. 3.

The field coil *F* consists usually of a single coil supported as explained above. The conditions for proper ventilation and protection are ideal, and for repairs the coil can be easily removed through the front of the machine after the rotor is taken out. The armature coils *L* are machine form wound and are readily accessible for repairs or removal as stated above.

The auxiliary or equalizing coil *H* is connected in series with the main field coil but in the reverse direction. It is supported by the cast-iron coil case *C* attached to the front pedestal, and has threaded upon it the cast-iron ring *M*. This movable ring allows for an adjustment of the air gap *N* by means of which the shaft leakage is neutralized, and the slightly unbalanced end play of the rotor compensated for. When this adjustment of the movable ring is once made the rotor remains balanced for all loads, and floats in its bearings.

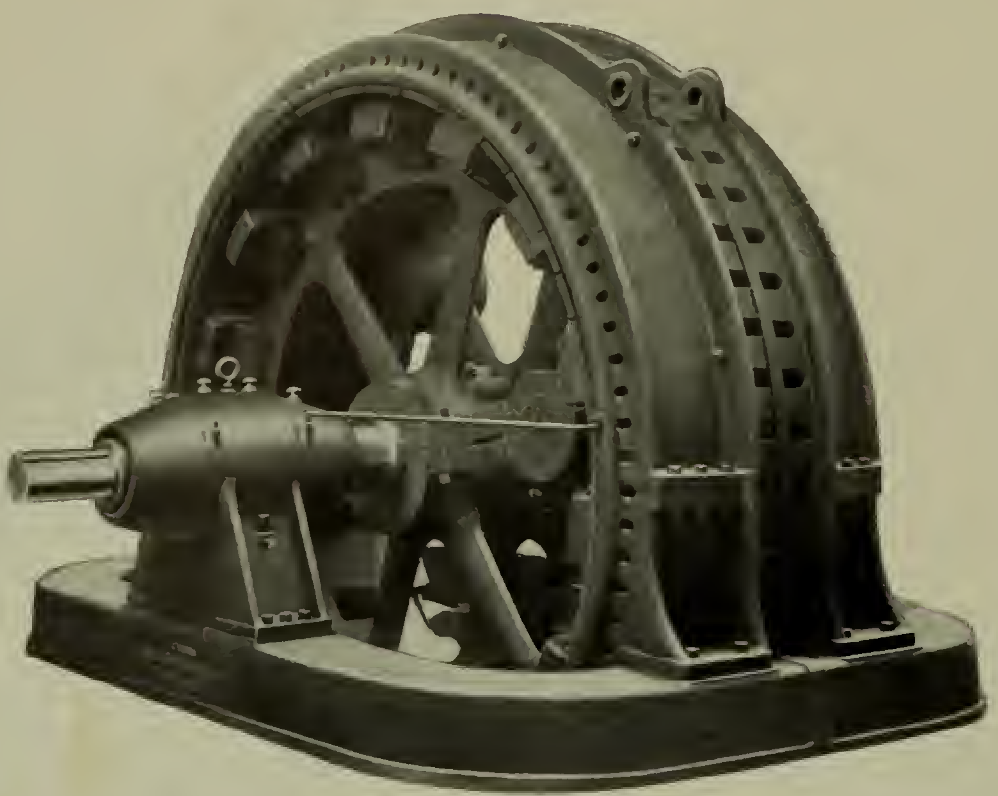


FIG. 8.—A 2000-KW. WATER-WHEEL TYPE OF INDUCTOR ALTERNATOR BUILT BY THE STANLEY-G. I. ELECTRIC MANUFACTURING COMPANY, OF PITTSFIELD, MASS.

Fig. 8 shows an inductor alternator built by the Stanley-G. I. Electric Manufacturing Company, of Pittsfield, Mass. Fig. 6 is a view of the rotor. In Figs. 5 and 7 the construction of the armature and rotor may be readily seen. On the face of the rim of the rotor, the lugs *B* are cast for the purpose of holding the laminations *N*, which form the pole pieces. A key *C* is screwed to the lug, and over it are slipped the laminations, having a slot *D*. The whole is held in place by the retainer *E*.

The armature laminations *K* are slipped over the bars *F* and held in place by the outside rings *L*. Heavy steel stiffeners *M* are placed at each end of the laminated iron.

The Single-Phase Railway Motor

By WALTER I. TAMLYN

UNTIL recently there were but two types of alternating-current motor on the market: the synchronous motor and the induction motor. As is well known, the synchronous motor will not start up from rest under load, but must be brought up to synchronous speed by some auxiliary source of power, when it will continue to rotate at this speed, independent of the load up to several times full load. Of course such a motor could not be used for railway work.

The polyphase induction motor will start up under load, but it is practically a constant-speed motor, and its efficiency at any speed can never be as great as the ratio of that speed to the synchronous speed. Single-phase induction motors will not start up under load. Induction motors have been used on several European roads, variable speed being obtained at the expense of efficiency by means of heavy and complicated auxiliary devices. The fact that these motors are necessarily polyphase is another great disadvantage since it requires at least two trolley wires.

In this country instead of using the unsuitable induction motor, the attempt was made to develop a new type of alternating-current motor, which should have the proper characteristics for traction purposes, and, in addition, work on a single-phase circuit. To this end a number of motors were suggested, such as the compensated series, the transformer series, and the repulsion motor. Of these, the compensated series motor seems to be the most satisfactory.

It is a well-known fact that if the current be reversed in direction in both the field and the armature windings of a direct-current series motor, the direction of rotation of the motor will not be changed. If then an alternating electromotive force be applied to the terminals of such a machine, it will rotate in the same direction as when running on direct current, since the current will simultaneously reverse in direction in both the field and the armature. But when so operating the motor has a low efficiency, a low power factor, and sparks dangerously.

The low efficiency is due mainly to the fact that in addition to the losses present in the direct-current motor, there is a large hysteresis loss in the entire magnetic circuit. This loss is caused by the alternating flux, which also sets up in the field windings an electromotive force of self-induction. The latter acts to reduce the power component of the electromotive force impressed on the power.

In Fig. 1, *AD* represents the reactive electromotive force of the field winding, *AB* the component of the impressed electromotive force which neutralizes *AD, AC* the electromotive force on the armature, or the power component of the impressed electromotive force; and *AE*, which is the resultant of *AB* and *AC,* the electromotive force impressed on the motor terminals. The

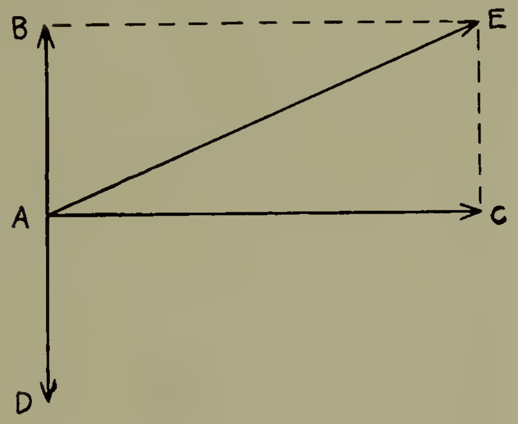


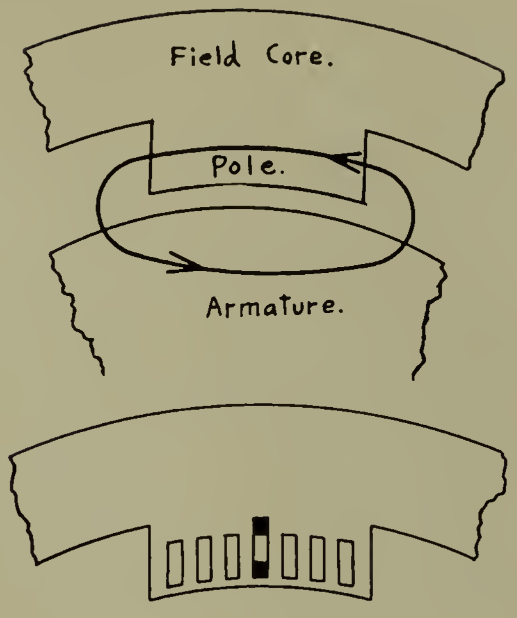
FIG. 1

power factor equals the ratio of the power component to the total electromotive force, thus,

$$\text{power factor} = \frac{AC}{AE}$$

In other words, neglecting the small I^2R losses, the power factor is approximately equal to the ratio of the armature counter electromotive force to the applied electromotive force. Since the electromotive force of field self-induction of a direct-current series motor when operating on alternating current is large, it follows that the power factor is low.

The commutation of such a motor when so operating will be very bad, principally on account of the fact that when an armature coil is short-circuited by a brush, it has linked with it an alternating flux from the field. The coil then has induced in it an alternating electromotive force, which, on account of the low resistance of the coil, the two leads and the brush contact, causes a heavy current to flow through this circuit.



FIGS. 2 AND 3

The rapid breaking of these circuits, in each of which the electromotive force tends to continue the current, produces the injurious sparking.

It is true that the sparking with direct current has a similar cause, being due to the reversal in direction of the current in the coil producing in it an electromotive force of self-induction. But in the case of the alternating current, this electromotive force of self-induction is superimposed upon the electromotive force induced by the field flux, so that the resulting sparking is worse.

It is obvious that such a motor could not be efficiently employed with alternating current. At the same time, however, it is remarkable that in spite of the above difficulties, the compensated-series alternating-current motor is simply a modified direct-current series motor.

To reduce the eddy current loss due to the alternating flux, the field magnet core must be built of thin laminæ. As may be seen from Fig. 1, the power factor will be raised if *AD*, the electromotive force of field self-induction, is made smaller, or *AC*, the power component, is made larger.

With a given load, the only way in which *AC* may be made larger is by increasing the losses. This, however, is not permissible. But *AD* may be made smaller by suitable relations and proportions between the parts of the motor, and between the motor as a whole and its conditions of operation.

As stated above, the power factor is approximately equal to the ratio of the armature counter electromotive force to the applied electromotive force; and therefore to secure a high power factor, the ratio of the field electromotive force of self-induction to the armature counter electromotive force should be made as small as possible. The electromotive force of field self-induction is proportional to the product of the alternations of the supply circuit, the number of field turns in series, and the flux per pole. The counter electromotive force of the armature is proportional to the number of revolutions per minute, to the number of armature inductors and to the flux per pole. It is assumed that the armature winding is of the usual multiple type.

The relation between the electromotive force of field self-induction and the armature counter electromotive force may then be expressed as follows:—

$$\frac{\text{E. M. F. of field self-induction}}{\text{Armature counter E. M. F.}} = \frac{\text{Line alterations} \times \text{field turns in series} \times \text{flux per pole}}{\text{Revolutions} \times \text{No. armature inductors} \times \text{flux per pole}} \times \text{constant (1.)}$$

$$\frac{\text{E. M. F. of field self-induction}}{\text{Armature counter E. M. F.}} = \frac{\text{Line alterations}}{\text{Poles} \times \text{revolutions}} \times \frac{\text{field ampere-turns}}{\text{armature ampere-turns}} \times \frac{\text{constant}}{2} \quad (2.)$$

The constant depends upon the characteristics of the line, and the units in which the several terms are expressed. Equation (2) follows from equation (1), since twice the number of armature turns in series multiplied by the number of poles equals the number of armature inductors, and the current in amperes is introduced in both numerator and denominator. As shown above, the first member of equations (1) and (2) should be made as small as possible. To secure this result it is evident that the terms in the numerator of the second member of equation (2) should be made small as compared to the terms in the denominator. That is, the frequency of the supply cir-

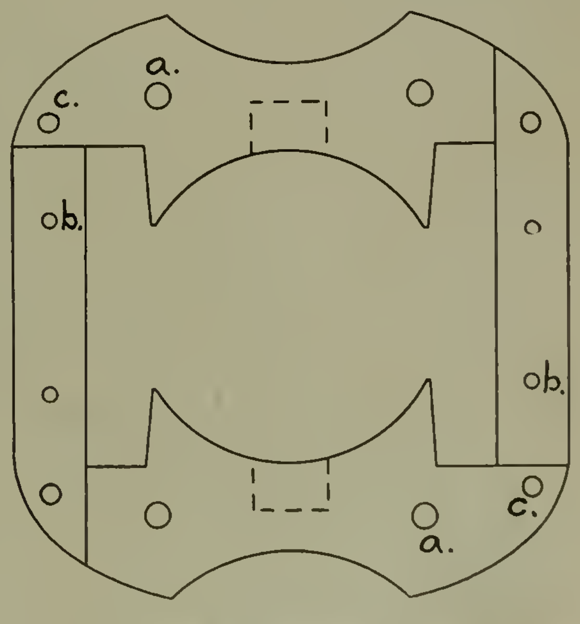


FIG. 4.—FORM OF LAMINATED FIELD OF AN EXPERIMENTAL SINGLE-PHASE MOTOR BUILT BY THE AUTHOR

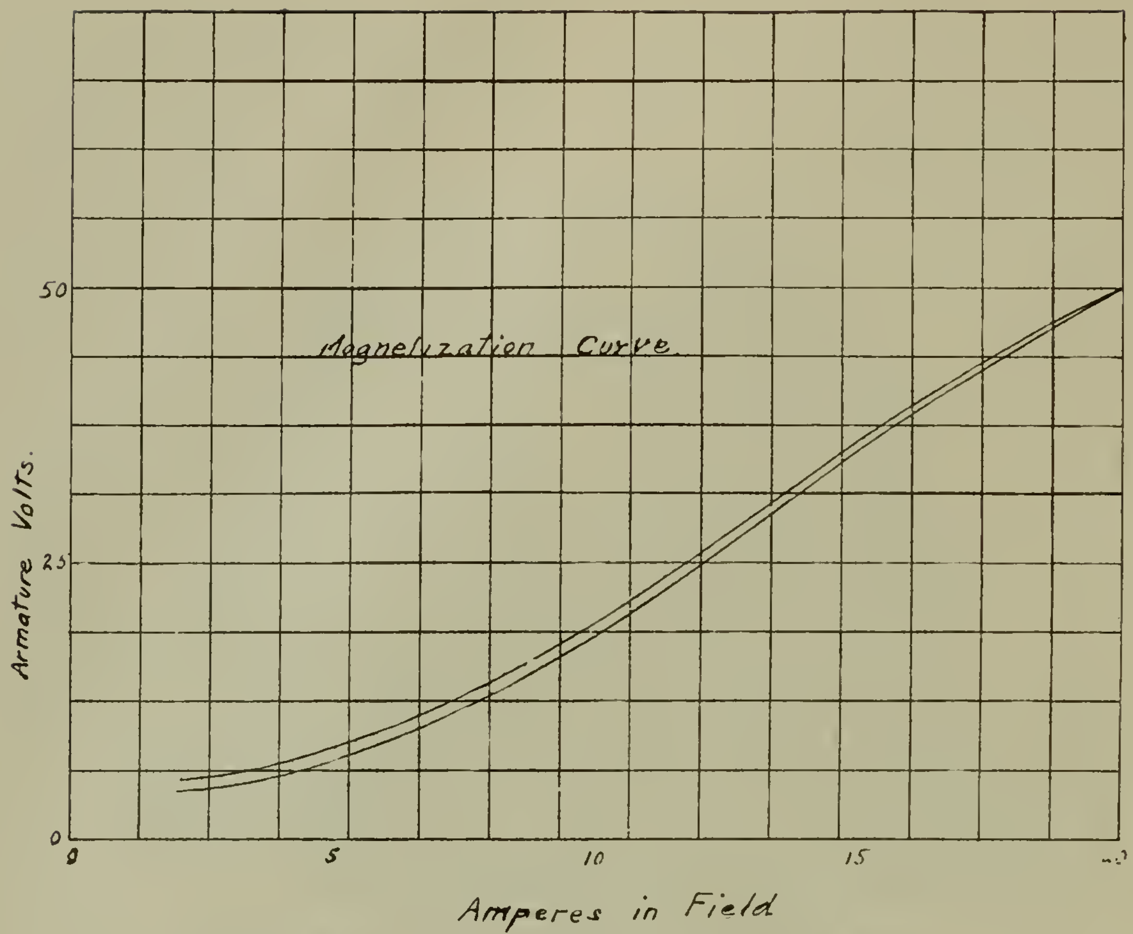


FIG. 5.—MAGNETIZATION CURVE OF A SINGLE-PHASE MOTOR

cuit should be low, while the number of poles and the rate of revolution should be high, and at the same time the ratio of field turns to armature turns should be made small.

The actual values of these ratios are limited by practical considerations, and they cannot be increased or decreased indefinitely. If, with a given magnetic circuit, the ratio of field ampere-turns to armature ampere-turns be too small, the field will be distorted, causing bad commutation.

The number of field ampere-turns may be reduced without weakening the field, if the reluctance of the magnetic circuit be proportionately decreased, either by increasing its cross-section or by using a smaller air gap. Enlarging the cross-section would make the motor larger and heavier, whereas railway motors must be built as small and light as possible, and the hard service to which such motors are subjected sets a minimum limit to the length of the air gap.

The ratio of field ampere-turns to armature ampere-turns must in general be larger than 0.5, and it may sometimes be as large as 0.75, and 0.625 may therefore be taken as an average value. The value of the constant divided by 2 is approximately equal to the reciprocal of 0.625, so that the last two terms in the second member of the equation (2) cancel. Since the value of the first member of the equation is limited by the desired power factor as explained above, it follows that this practically limits the value of the remaining term of the equation. That is, with a given number of revolutions, the number of poles must increase directly as the line alternations. For example, if on a circuit having a frequency of $16\frac{2}{3}$ cycles per second, a four-pole machine is required, then a six-pole machine will be required on a circuit having a frequency of 25 cycles, the speed being the same in the two cases.

Although neglected above, the armature electromotive force also has an inductive component. This results from a cross-induction through the poles, set up by the currents in the armature coils. The path of the magnetic lines of force so produced is shown in Fig. 2. If now the pole is constructed with a number of slots, as shown in Fig. 3, the reluctance of the path of these lines is much increased.

The effect of the slots may be made greater if copper conductors, or, better still, coils of wire are placed in one or more of the slots, as shown in the cross-section in the middle slot of the pole in Fig. 3. These coils, known as compensating coils, tend to prevent the flow of magnetic lines of force in the general direction indicated in Fig. 2. In this way they more or less completely eliminate the inductive component of the armature electromotive force due to the cross induction through the poles.

When the field core is saturated, no further increase of current can increase the field strength. Consequently it is desirable to work the field core at a flux density below saturation until the current has exceeded the normal full load value. Otherwise the torque, which is proportional to the field strength, would not increase as fast as it should with increased currents.

The field yoke should be worked at a low density to lessen as far as possible the iron loss due to the reversals of flux, and the magnetic leakage through the surrounding metal. At the same time the stronger the poles are magnetized the less the field will be distorted by the cross magnetization of the armature. As

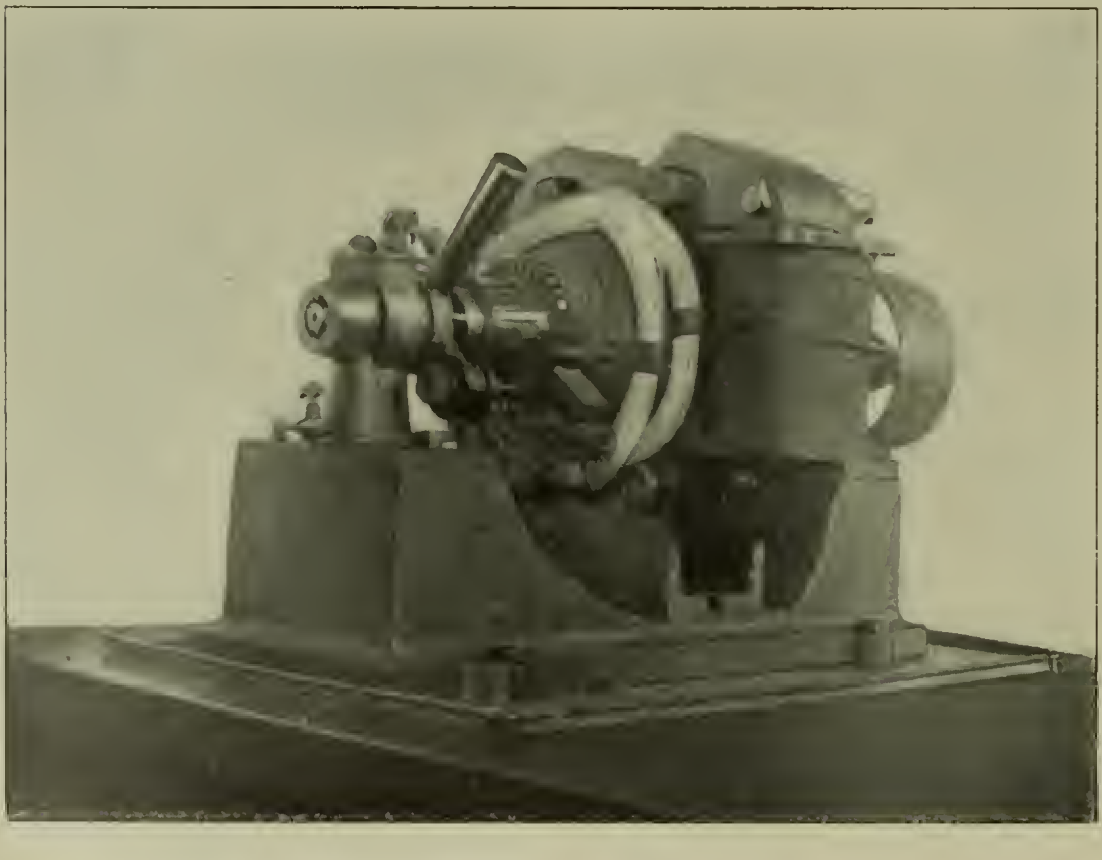


FIG. 6.—AN EXPERIMENTAL SINGLE-PHASE MOTOR CONSTRUCTED BY THE AUTHOR

previously pointed out, the larger the cross-section of the air gap, the smaller is the number of field ampere-turns required to produce the necessary flux, and the lower is the value of the field electromotive force of self-induction. It is for this reason that the slots for the compensating coils are closed or nearly closed at the pole face.

To fulfill these requirements, the poles should be built as shown in Fig. 3, the net cross-section of metal back of the pole face being worked at such a high flux density as to become saturated when the current has slightly exceeded the rated full-load value; and at the same time the rest of the field frame should have as large a cross-section as the available space for the motor will allow.

The usual flux through the armature from the field coils sets up electromotive forces of self-induction in the armature windings; but these electromotive forces neutralize each other since they add to the armature counter electromotive force in one part of the winding and subtract from it at another. They are consequently of no importance, except in coils short-circuited by the brushes, where they are likely to produce injurious sparking.

It was shown above that the commutation of alternating current differs in degree, but not in kind from that of direct current. To reduce both the electromotive force of self-induction, and that induced by the field flux, the number of turns in series in a single coil may be reduced; and to reduce the current due to these electromotive forces, the resistance of the coil may be increased. The resistance of the coils could not be increased by decreasing the size of the wire, since the current-carrying capacity of the inductors would be correspondingly decreased, and the I^2R loss would become very large.

If, however, the ends of the adjacent coils be connected together (the winding was assumed to be of the multiple type) and each of these junctions be connected to a commutator segment by a lead having a resistance which is high as compared to that of a coil, the desired result will be accomplished. The loss of energy due to the drop of potential across the resistance will not heat them up to any extent, as the leads are in circuit but a fraction of the time; and moreover this loss will be small, since the actual resistance of the lead is low, and no more than two of them can ever be in series in the circuit.

The writer recently rebuilt a small direct-current motor, making it of

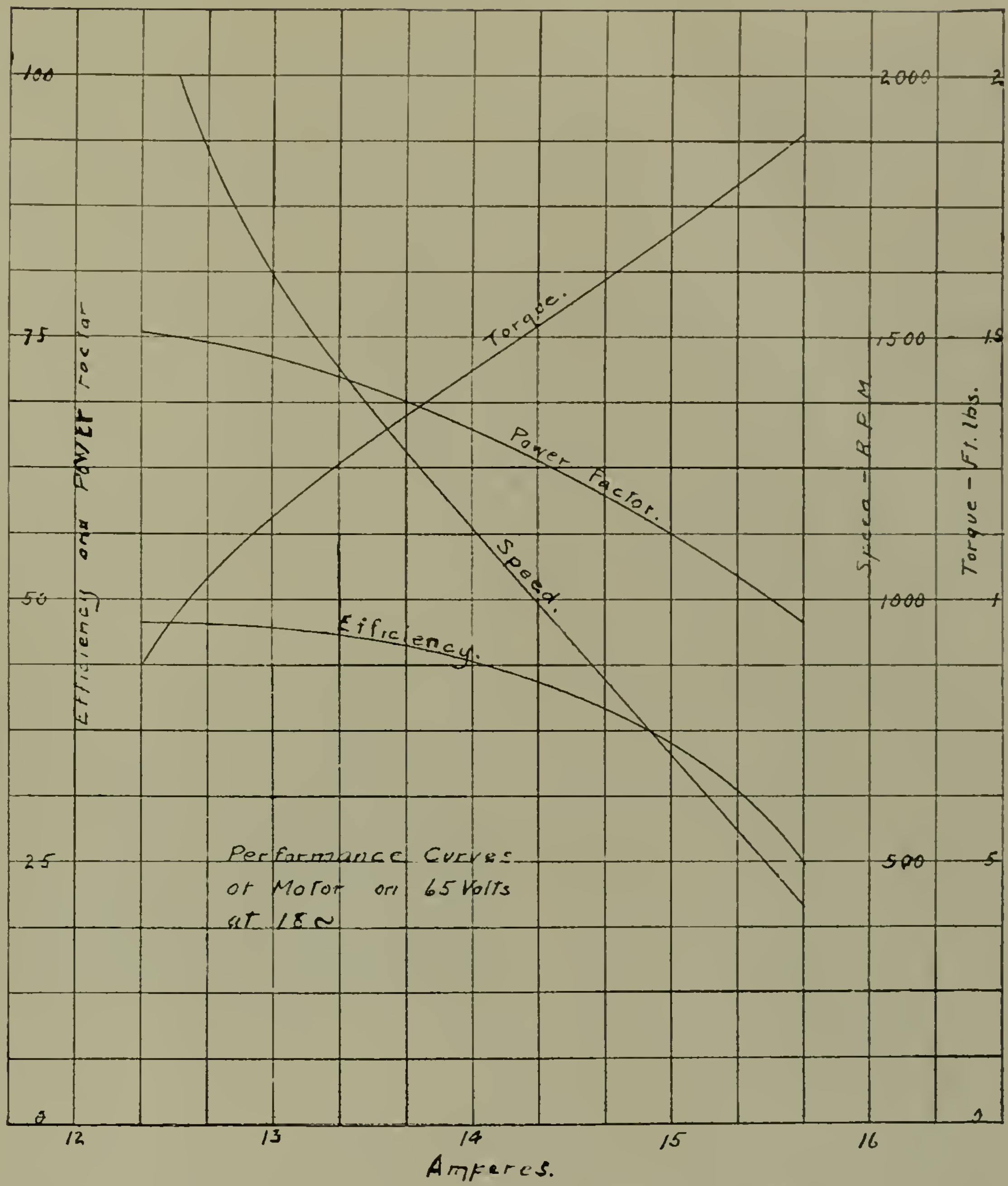


FIG. 7.—CHARACTERISTIC CURVES OF THE SINGLE-PHASE MOTOR SHOWN IN FIG. 6, WHEN OPERATING ON ALTERNATING CURRENT

the single-phase type. The motor chosen for the purpose was a direct-current shunt machine of old design, built by the Riker Electric Company, of Brooklyn, N. Y. The laminated field core is of the consequent pole type and is made up in four sections as shown in Fig. 4. The plates of the top and bottom sections are held together by bolts marked *a a*. The bolts in the bottom section also serve to fasten the field core to the bed-plate. The plates of the side sections, on which the spools carrying the field coils fit, are held together by rivets *b b*. The sections are dove-tailed at the corners and fastened by bolts *c c*. The armature coil is of the drum form with thirty slots, and as the commutator contains thirty segments, two coils must be wound in each slot. Both the field winding and the armature winding were removed, as neither was suitable for a series motor.

Before unwinding the armature, the field core was taken apart and each plate given a coat of shellac varnish on both sides. In assembling the field, thin paper was put between the plates at about every tenth plate. A test field-winding of 100 turns per coil was placed in position and a magnetization curve obtained. The result is plotted in Fig. 5. The area enclosed by such a curve is proportional to the energy lost in hysteresis while carrying the iron through a complete cycle. The small area enclosed therefore indicates that the hysteresis loss in the motor when running on alternating current is small.

The curve also shows that with 20 amperes through 100 turns, that is, a magnetizing force of 2000 ampere-turns per pole, the core has not reached the point of saturation. Consequently the new field coils were each wound with 100 turns of No. 10 copper wire. The armature coils were connected in multiple, and there being two wires in parallel carrying the same current as the single wire of the field coils, No. 14 wire was used. Each armature coil was wound with eight turns, making sixteen wires per slot. It was calculated that with such a small number of turns per coil, the commutation should be

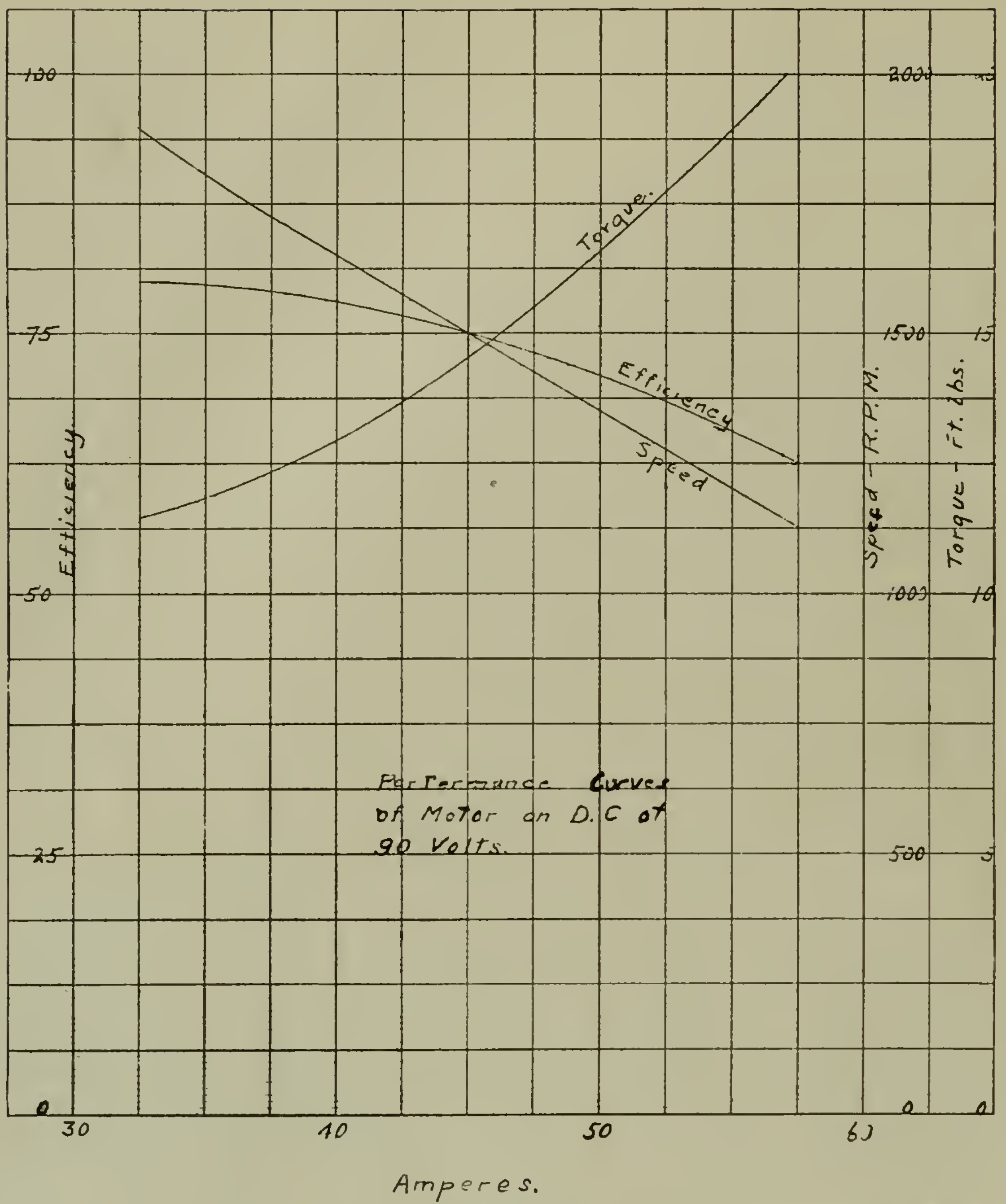


FIG. 8.—CHARACTERISTIC CURVES OF THE MOTOR SHOWN IN FIG. 6, WHEN OPERATING ON DIRECT CURRENT

nearly sparkless and no extra resistance leads were inserted between the coils and the commutator bars.

Four compensating coils, each containing 120 turns of No. 16 wire were wound upon a removable frame. These coils were inserted in slots cut in the middle of the pole faces as indicated by the dotted lines in Fig. 4, and the ends of the coils were bent right and left to clear the armature. Fig. 6 is from a photograph of the machine as it appeared when ready for testing, showing clearly the field coils and the compensating coils.

It had been intended to test the motor on a voltage of between 125 and 150 at a frequency of 20 cycles. The source of power was a rotary converter which could be driven by a shunt motor at any speed to obtain any desired frequency. A speed of 540 revolutions per minute, corresponding to 18 cycles per second, was found to be convenient, but as the normal speed of the rotary was from 1200 to 1800 revolutions, the voltage obtained at the reduced speed was very low. All the available transformers were for use on circuits of higher frequency, and so the highest voltage that could be obtained was about 60.

The results of the tests are shown in the form of curves in Figs. 7 and 8. An examination of Fig. 7 will show that both the efficiency and power factor are low. The speed and torque curves, however, have the proper relation for traction work.

The maximum current that could be obtained with 18 cycles was 17 amperes or about one-third of the permissible carrying capacity of the windings. The field flux was, in consequence, not so strong as it should have been, and necessitated a very high speed. The low power factor is accounted for by the neglect of many of the principles set forth above. This was unavoidable for mechanical reasons. For instance, the motor should have had more poles, but it was impossible to increase the number of poles; furthermore, the consequent poles caused a large magnetic leakage; the joints in the field frame and the large air gap made the reluctance of the magnetic circuit high; and the compensating coils were concentrated at the center of the pole faces instead of being distributed. Taking these unfavorable circumstances into consideration, the operation of the motor was probably as good as could be expected.

Fig. 8 shows the performance of the motor when operating on direct current. The efficiency is seen to be higher than when the motor is operating on alternating current, which, from the theory of the motor, is to be expected, because of the smaller losses with direct current.

There was one very important thing shown in the tests which does not appear in the curves, that is, the commutation, while not sparkless, was no worse than that of many direct-current machines when working on a small but allowable overload; but undoubtedly the commutation could have been made practically sparkless if high resistance leads had been inserted between the coils and the commutator bars.

It should be remembered in connection with these tests that they were made to show that a single-phase motor has the proper characteristics for railway work; that a given single-phase motor is more efficient on direct current than on alternating current; and that, with a small number of turns per coil and proper design throughout, the commutation of a single-phase motor causes no trouble whatever, and the tests made show conclusively that the motor possesses these qualities.

It would appear that the advantages of using the alternating-current railway motor do not arise from that motor being better than the direct-current type. On the contrary, the former is heavier, less efficient, and costs more than the latter. There are advantages, however, all of which are due to the use of a complete alternating-current power system with the ease of transforming current.

The Electrification of the West Jersey & Seashore Branch of the Pennsylvania Railroad

FIG. I.—THE POWER HOUSE OF THE WEST JERSEY & SEASHORE RAILROAD AT WESTVILLE, N. J.

THE Pennsylvania Railroad has equipped for electric operation its West Jersey & Seashore branch, involving the electrification of a main line double-track steam road from terminal to terminal of a greater length than any electrified steam road in the country.

This undertaking also involved the construction of a power house of original design and built in record time. The site for it was chosen on January 17, 1906; the first pile was driven two days later, and on July 1 the first train to take current from the power house was run on the newly electrified tracks. On September 18 the line was placed in operation for regular service.

The line of the electrified system extends from Camden, N. J., via Newfield, to Atlantic City, a distance of sixty-five miles, and from Newfield to Millville, a distance of ten miles. In addition to the erection of a power house, this work has called for the building of eight sub-stations, one of which is in the power house, the electrical equipment of approximately 150 miles of single track, the building of 71 miles of duplicate high-tension transmission line, and the construction and electrical equipment of sixty-eight cars. In addition, a great deal of other work, always incident to extensive undertakings of this nature, was done, such as relaying old track, building new track, installing block signals, stringing telegraph and telephone wires, building bridges and culverts, and moving passenger and freight stations.

FIG. 2.—THE STATION AT WESTVILLE, SHOWING CATTLE GUARDS, JUMPER BOXES, AND THIRD-RAIL COVERING

Beginning at the Camden end of the line, an entirely new terminal has been constructed adjoining the present ferry terminal. The work at this point includes a number of stub end tracks with suitable sheltered platforms between them, and three-quarters of a mile of new elevated double-track trestle, with stone piers and steel superstructure at street intersections, has been built to connect this terminal with the existing lines.

From a point about two miles from Atlantic City a new right of way has been secured, and after crossing the thoroughfare on a new drawbridge, the tracks cross the Philadelphia & Reading on an elevated structure and enter the Atlantic City terminal on a descending grade. From Camden to Atlantic City the road has been equipped with a third rail, with the exception of a stretch of track about four and one-half miles in length between Camden and South Gloucester, the track passing through the city streets at grade between these points being equipped with the overhead trolley.

In addition to this through route, the line from Newfield to Millville,—ten miles in length,—has been electrified. On this portion of the road the overhead trolley has been installed, and new terminal facilities have been provided.

From Camden to Atlantic City the line is a double-track road throughout, and is a three-track road between Camden and Woodbury.

It will be noticed on the map that the Pennsylvania Railroad Company

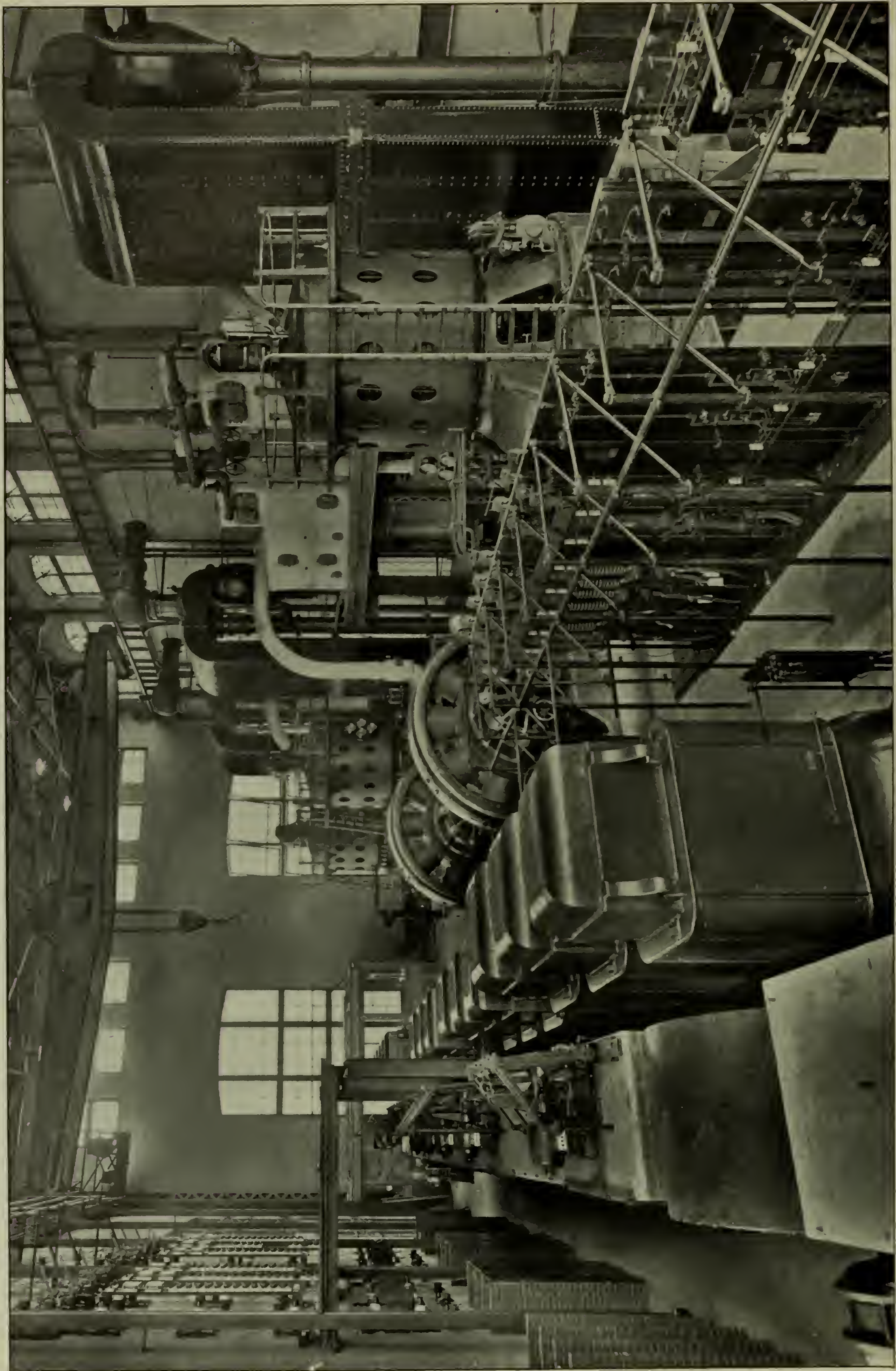


FIG. 3.—INTERIOR OF THE POWER HOUSE AT WESTVILLE, SHOWING THE THREE 2000-KW., 6600-VOLT CURTIS TURBINE GENERATORS, THE NINE TRANSFORMERS WHICH STEP THE PRESSURE UP TO 33,000 VOLTS, AND TWO 750-KW. ROTARY CONVERTERS

has two roads connecting Camden with Atlantic City, and it is the longer of these routes that has been electrified. This has been done because there is a large local traffic on the longer route that can be nandled more economically and expeditiously by electric traction than is possible with steam haulage.

The importance of the undertaking is further emphasized by the density of the traffic on the electrified section of the road. The power house and sub-station equipment and the line are laid out with a view of supplying sufficient power for the operation of all the cars now provided, operating an express service to Atlantic City consisting of three-car trains running on a headway of fifteen minutes in each direction at a speed, on straight, level track, of 60 miles per hour, and for a local service of two-car trains between Camden and Millville on half-hour intervals, and single cars between Camden and Woodbury on ten-minute intervals.

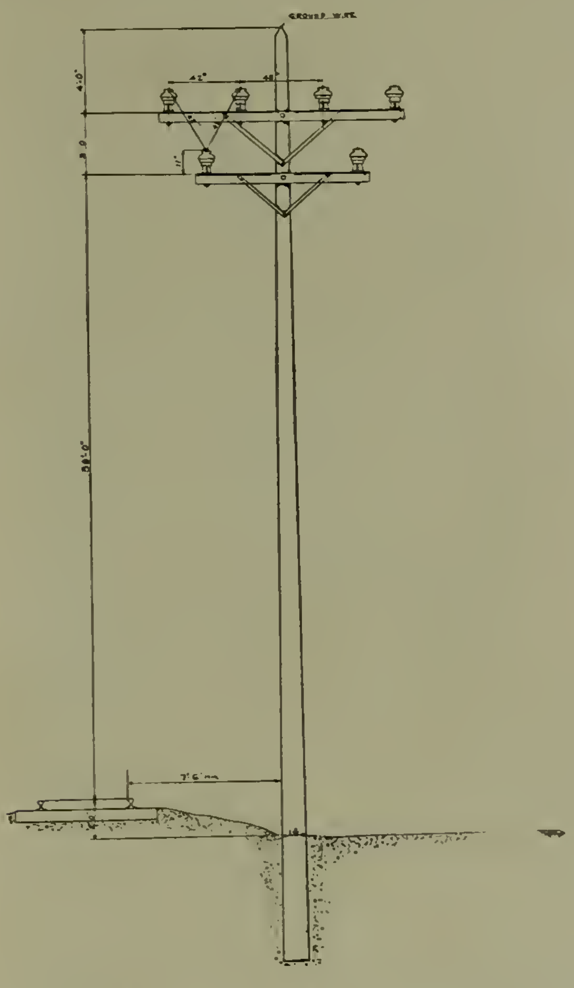


FIG. 4.—A POLE USED ON THE HIGH-TENSION TRANSMISSION LINE

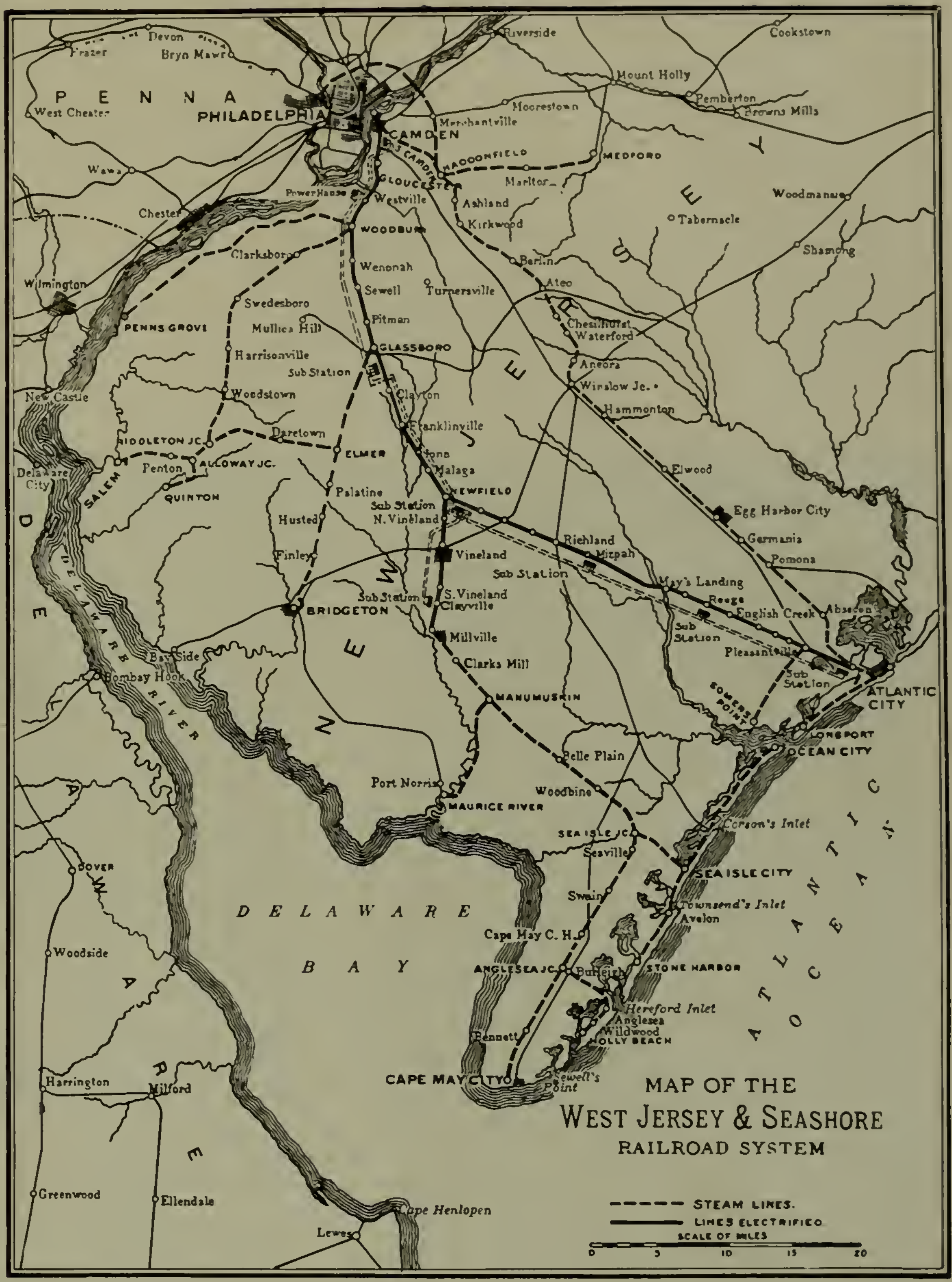


FIG. 5.—MAP SHOWING THE ELECTRIFIED SECTIONS OF THE LINE

The initial schedule that has been put into service includes three-car express trains between Camden and Atlantic City on one-hour intervals, the running time being ninety minutes, and a local service of two, three and four-car trains running on a minimum interval of fifteen minutes during the rush hours between Camden and Glassboro, every fourth train going on to Millville. The motor baggage and mail cars are attached to the passenger trains as conditions require.

As described elsewhere, provision is made in the power house and sub-stations for increasing the equipment to accommodate the heavier traffic which is expected to result from the improved service. It should be mentioned that each car in the electric service is a motor car, no trailers being used.

The contract for the entire electrification work was given to the General Electric Company, and through them certain portions were sub-let. The electrical equipment throughout is of standard General Electric design.

The general scheme of electrification consists of generating alternating current at a potential of 6600 volts at the power house, where it is stepped up to 33,000 volts. At the latter pressure it is transmitted over the high-tension transmission lines to the sub-stations, where it is reduced to a potential of 430 volts by means of step-down transformers, and then led to the rotaries and converted to direct current at 650 volts, at which pressure it is fed to the third rail for operating the cars.

Fig. 1 shows the power house, which is situated at Big Timber Creek, just to the north of Westville, N. J., at a point somewhat more than five and one-half miles from the Camden terminal. An abundance of water is available for boiler feed and condensing purposes.

Three-phase current for transmission is supplied by three 2000-KW., 6600-volt, 25-cycle Curtis turbine generators, while the exciting current is supplied by two 75-KW., 125-volt machines, also driven by Curtis turbines. Current is stepped up to the transmission pressure of

33,000 volts by nine 700-KW., 25-cycle, air-blast transformers. While the present normal capacity of the power station is, therefore, 6000 KW., there is, however, sufficient room provided in the layout of the building for an additional 2000-KW. turbo-generator set, together with the necessary auxiliaries. The foundation for the extra turbine is already built. In addition to this provision for extra power, one of the end walls of the station is of a temporary nature, in order that increasing demands for power may be met with

FIG. 6.—THE BOILER ROOM IN THE WESTVILLE POWER STATION. TWELVE WATER-TUBE BOILERS BUILT BY THE STIRLING CONSOLIDATED BOILER COMPANY, NEW YORK, AND PROVIDED WITH SUPERHEATERS, GENERATE STEAM AT 175 POUNDS

a minimum of expenditure in the future.

In the boiler house, shown in Fig. 6, are twelve Stirling water-tube boilers, arranged in pairs forming six batteries. Each boiler is rated at 358 H. P., and is furnished with a superheater capable of delivering steam at 175 pounds pressure and at a temperature of 125 degrees F. in excess of that of saturated steam.

In eight sub-stations distributed along the line, the high-tension, three-phase current is reduced in pressure and converted to a direct current at 650 volts. One is located in the power house at Westville, and three terminal sub-stations are situated, respectively, at South Camden, Clayville, and Atlantic City, and four intermediate sub-stations, one at Glassboro, one at Newfield, one at Mizpah, and one at Reega. The interior of the Atlantic City station is shown in Fig. 12, and the exterior of the Glassboro station in Fig. 10.

In the different sub-stations the equipments vary according to the requirements of the portion of the road they supply. Table I. shows the number and capacity of rotary converters installed in each sub-station, together with the extra capacity provided for.

Three air-cooled transformers are provided for operation in conjunction with each rotary, and these are located in each case with a view to the further extension of the sub-station. The transformers are all supplied with taps giving one-third and two-thirds of the working voltage to enable the converters to be started from the alternating-current side. This method of starting needs no synchronizing, and should the direct-current polarity of the machine chance to come in the wrong direction it is readily changed by means of the field reversing switch provided for this purpose. By this method, any of the rotary converters can be started, run up to full speed, and be delivering power to the line within a minute.

Fig. 11 shows the disconnecting switches and lightning arresters as located in a separate room in each

TABLE I.

Name of Sub-statson.	KW. Capacity of Rotary Converters Already Installed	KW. Capacity of Additional Rotary Converters Provided for.
South Camden	2—750	1—750
Westville (in power house)	2—750	1—750
Glassboro	2—750	1—750
Newfield	2—750	1—750
Clayville	2—500	1—750
Mizpah	2—500	1—750
Reega	2—750	1—750
Atlantic City	2—750	2—1000

sub-station; the high-tension circuits are of bare copper wires supported on insulators on a pipe framework, and each pole of the oil switches is enclosed in a separate brick compartment.

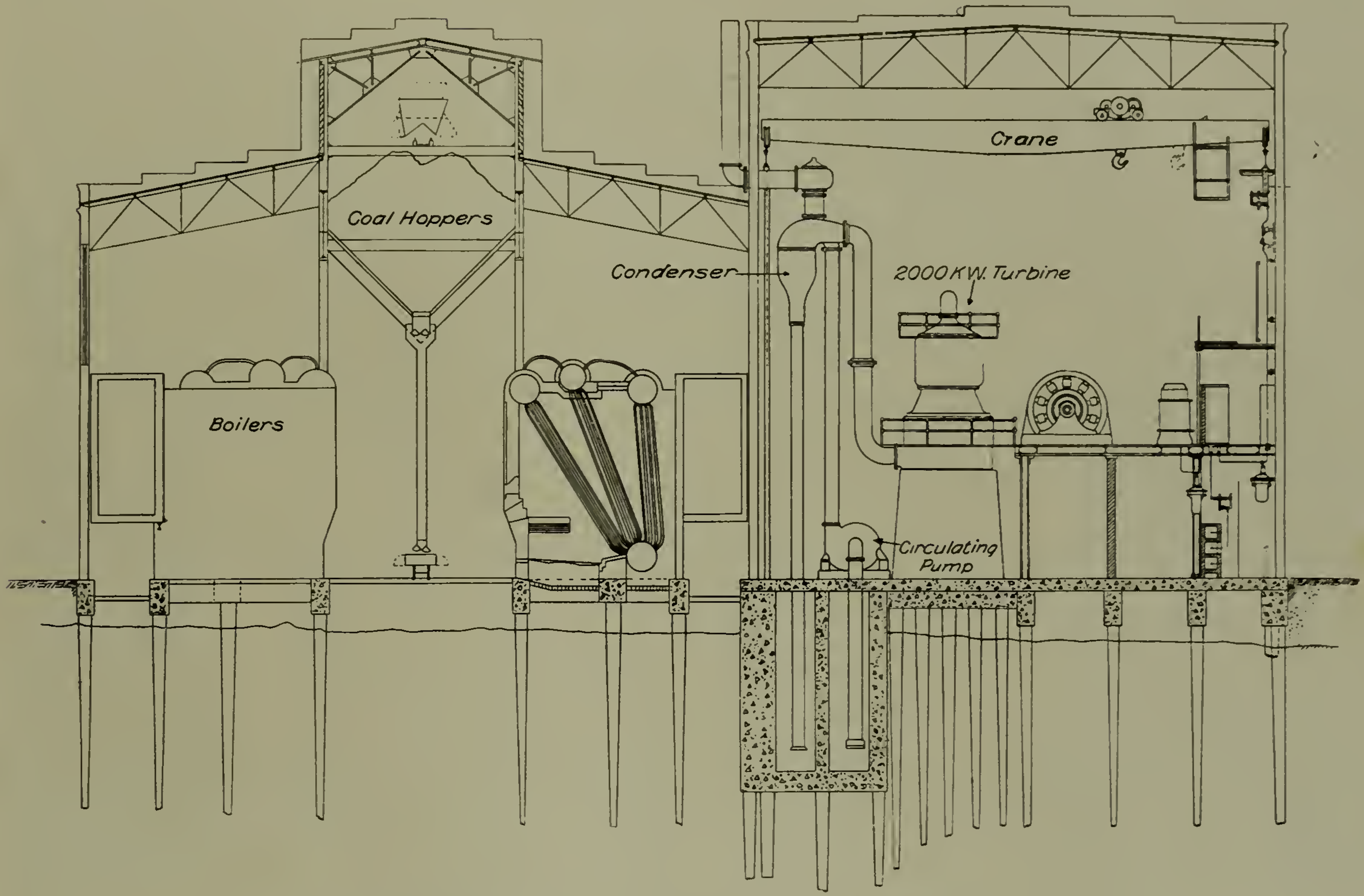


FIG. 7.—TRANSVERSE SECTION OF THE POWER HOUSE AT WESTVILLE, N. J.

The sub-station buildings are of red brick, trimmed with Indiana limestone facings, and the floors are of concrete. Each sub-station is furnished with a hand-operated crane, capable of handling any of the machinery installed.

It is a matter of interest that the sub-station buildings, including the foundations, were built in sixty working days, and that the installation of machinery was accomplished in thirty working days.

The 330,000-volt, high-tension transmission line is in duplicate throughout. It is Y-connected with the neutral grounded, and consists of six No. 1 B. & S. hard-drawn, solid copper wires mounted on porcelain insulators. Chestnut poles are used, their height being 45 feet, with extra long poles where special conditions require. A spacing of 125 feet was adopted, but at street crossings the spacings are reduced to 100 feet.

Of the two cross-arms, the top arm is 12 feet in length, and carries four insulators, the lower arm, which is 8½ feet in length, carrying two insulators. As will be seen in Fig. 4, the six wires form two inverted equilateral triangles, and the insulators on each triangle are 42 inches apart. These wires in each triangle are transposed by one complete revolution between each sub-station. The insulators are of the 3-petticoat type, manufactured by the Locke Insulator Manufacturing Company, of Victor, N. Y.

A unique feature of the transmission line is the method of protection from lightning, which consists of a seven-strand galvanized steel cable, 5-16 inch in diameter, strung for the entire length of the line on top of the transmission poles, 4 feet above the nearest active wire, and provided with ground connections at every fifth pole. This form of protection from lightning is believed to be an efficient supplementary adjunct to the arresters.

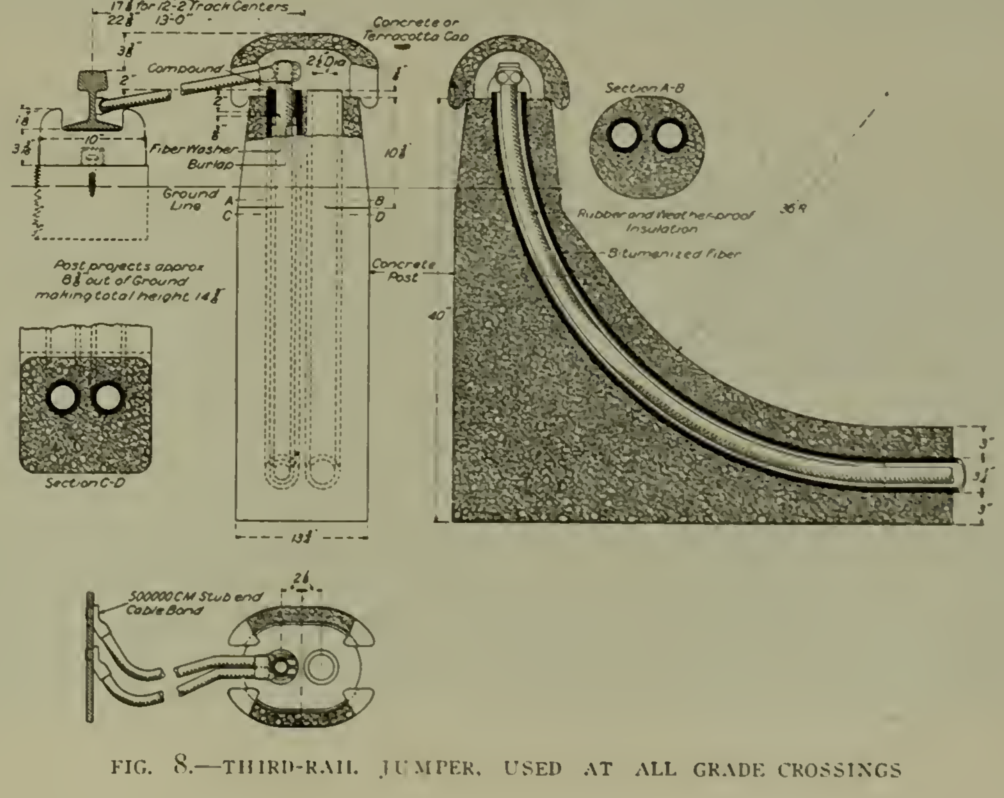


FIG. 8.—THIRD-RAIL JUMPER, USED AT ALL GRADE CROSSINGS

FIG. 9.—A STEEL MOTOR CAR ON THE WEST JERSEY & SEASHORE BRANCH OF THE PENNSYLVANIA RAILROAD

In all, there are seventy-one miles of transmission line. This was erected at a speed of from one-half to two miles a day, the work including the digging of holes and pole erection, besides the stringing of six wires and tying them in position to their respective insulators.

The proposition of installing the third rail for the double-track road of this length in the prescribed time demanded a considerable amount of skill on the part of those organizing the work, and the fact that a large amount of steam traffic and double-tracking was going on at the same time materially added to the difficulties of the undertaking.

The Pennsylvania Railroad Company provided and installed all the necessary long ties on which the insulators are placed, and they also provided and distributed along the track all the third rail, third-rail splice bars and bolts. The rails used for this purpose are of the Pennsylvania Railroad standard cross-section and composition. This type of third rail was used in order that it might be interchangeable with the track rails.

Fig. 8 shows the third-rail jumpers which are used at all grade crossings and wherever a continuous third rail is impracticable. The cable is drawn into a black bituminized fibre tube, which is laid in a solid concrete protection. The illustration shows a double jumper. Terra cotta covers are employed to protect the cable terminals. Those for single cable jumpers are of the round form and those for double cable of an elliptical shape, as shown.

The third rail is anchored at intervals by means of metal clamps secured to the under flange of the rail in such a position as to engage the insulator on either side. The third rails are arranged in such a manner that each track may be isolated from the other, but normally the third rails are electrically connected midway between the sub-stations through a combined switch and fuse box, thus obtaining the combined conductivity of the third rails. There are also section insulators opposite each sub-station, so that in the event of an accident on any part of the system only a short section of the third rail would be dead.

The company's right of way is fenced in, and at all crossings the fence turns in from the property line to meet Climax cattle guards at the edge of the crossing. In this way the public is prevented from reaching the third rail. At all stations and in the Atlantic City and Camden yards the third rail is protected by a wooden top and side guard, as shown in Fig. 2. This consists of 2-inch plank carried on castings attached to the top of maple posts. which are secured to the third rail at intervals of about 6 feet.

FIG. 10.—EXTERIOR OF THE SUB-STATION AT GLASSBORO

Opposite all platforms the rails are

FIG. 11.—THE LIGHTNING ARRESTER ROOM IN THE SUB-STATION AT NEWFIELD, SHOWING ALSO THE DISCONNECTING SWITCHES

further protected by a plank fastened to the side of the rail. Wherever possible, the rail is kept between the tracks, and is, therefore, on the side of the track farthest from the station platform, and inter-track fences are provided to prevent crossing the tracks. In order to prevent passengers or others on the platforms from touching the contact shoes on the platform side of the car, there is a protecting plank similar to the third rail protecting plank, but carried on castings fastened to the ties. The shoes are at all times under this plank, and, therefore, protected. This is used at all stations, even where the third rail gives way to the trolley, although there is a switch on the car switchboard which enables the contact shoes to be cut out when operating from the trolley.

At Atlantic City, where the tracks cross the thoroughfare, a new drawbridge has been built. The third rails on this draw are connected to the third rails on the approaches by sliding contact shoes, so that when the draw is closed the rail is continuously connected. In addition to this, two 1,000,000 c. m. submarine cables are provided, connecting the rails so that the opening of the draw does not interrupt the circuit. The submarine cables for the return circuit are bare.

A point of great interest is to be found in the fact that the third-rail system has been adopted at both terminal stations where there are a number of platforms, and it will be interesting to engineers to learn that this system was adopted on the score of less difficulties being encountered in its installation than would have been the case had an overhead trolley been erected.

The bonding of the main track between Camden and Atlantic City was a work of great magnitude, which will be appreciated when it is remembered that a heavy steam traffic was in progress during the whole period. It is a matter of interest to know that all the holes were drilled by hand, and also that the bond terminals were expanded

FIG. 12.—INTERIOR OF THE ATLANTIC CITY SUB-STATION. THE HIGH-TENSION, 3-PHASE CURRENT IS REDUCED IN PRESSURE AND CONVERTED TO DIRECT CURRENT AT 650 VOLTS BY SIX AIR-COOLED TRANSFORMERS AND TWO 750-KW. ROTARY CONVERTERS

by means of screw compressors. Two bonds of the "concealed" type were used per joint, each with a capacity of 400,000 c. m., and on account of the large size of bonds special angle plates had to be provided. As the road is double track throughout on the main line, the rebonding required the drilling of a prodigious number of 1-inch holes.

This work was performed almost entirely with untrained labour, under skilled foremen. The men were given a royalty of five cents on each hole drilled above thirty per day, and some reached as high a maximum as eighty in a day's work. The company required that one splice bar should always be kept in place against the rail to provide for the safe operation of the passing trains.

Between Newfield and Millville and on the stretch of track between Haddon avenue and South Gloucester the trolley construction is of the span type, with poles spaced at a distance of 100 feet, and, where practicable, the high-tension transmission poles have been used for supporting the span wires. Through Camden the greater part of the trolley construction is on tubular steel poles. The trolley is suspended 22 feet above the top of the track rails.

For initial service sixty-two passenger cars and six combination baggage and mail cars have been provided. All of the cars are motor cars, the motor and control equipment being the same on all.

In preparing the design of these cars, the engineers of the railroad followed the general design of the standard Pennsylvania Railroad coaches, except that the height is less than the standard, to decrease the weight, the shape of the roof is changed, and the interior finish is of mahogany instead of oak. These cars also differ in some other details, such as colouring of the seats, tne basket racks, sash fixtures and lighting fixtures.

The seating capacity is fifty-eight passengers. Both ends of the cars are provided with vestibules, and have the standard arrangement of steps, trap-doors and vestibule side doors, with standard equipment of bronze hardware and grab handles. The vestibule centre door is so arranged that when it opens it slides over and encloses the control apparatus.

Each car has two trolleys, each with a retriever, and on the roof between the trolley bases there is a box in which are placed the lightning arrester, the trolley cut-out switch and the trolley fuse.

In the vestibule, at the saloon end of the car, on the motorman's side, a switchboard is installed, on which are mounted the headlight and air-compressor switches and fuses, the switch for cutting out the contact shoes when operating on trolley, and the trolley cut-out switch and current limit relay. This switchboard is provided with double steel doors lined with asbestos, and is accessible from the vestibule.

Two 200-H. P. motors are provided on each car, the control system being of the Sprague-General Electric multiple-unit type. The controllers are so arranged that current is cut off from the motors throughout the train, and the brakes are applied automatically should the motorman release his hold of the controller handle.

A large portion of the electrical apparatus was installed on the car bodies during their construction at the works of the car builders. All the cables for the electrical conduits are run in grounded loricated conduits the outlets of which are provided with rubber-bushed bell-mouths.

On account of the short time at the disposal of the contractors, it was not possible to follow the usual cut-and-try methods in installing the brake and control apparatus and piping, and carefully made detailed drawings of all conduit work and hangers were prepared in advance and the equipments were installed simultaneously at the three car shops in accordance with these plans as soon as the car body framing was sufficiently advanced to permit it, thus securing uniform and interchangeable work. The greatest care and attention was given to all details of the conduit and wiring, and all circuits were tested with high-potential alternating current after completion. It is safe to say that a more carefully thought out and installed piece of car wiring has never been done.

For the sake of brevity, these equipments will not be entered into in detail, as they are of standard General Electric design. With the exception that each car is provided with a trolley and third rail shoe, the control system is similar to that on the twenty-four equipments supplied to the Boston Elevated road and those built for local traffic on the New York Central's electrified zone.

The entire contract for the electrical equipment, including the construction of the power house, substations and the electrical equipment on the cars, was awarded to the General Electric Company, and in accordance with the plans and under the supervision of George Gibbs, chief engineer of electric traction in consultation with the officers of the Pennsylvania Railroad Company.

The whole of the electrical work was under the personal supervision of W. B. Potter, engineer, railway engineering department of the General Electric Company, directly assisted by J. Elliot Hewes, C. E. Eveleth and W. H. Clapp.

Elevated Railways and their Bearing on Heavy Electric Traction

By H. M. BRINCKERHOFF

A Paper Read at the Recent Convention of the American Street and Interurban Railway Engineering Association

WHEN entering upon a new field of activity, or upon a line of work exceeding in magnitude anything heretofore attempted, one naturally looks about in an effort to ascertain what has been done in similar undertakings that may in one way or another supply some useful lesson or be a guide in shaping the new development.

The demand for greater terminal facilities for the steam railroads in our great cities and the necessity for doing away with the smoke incident to steam locomotive operation in the tunnel approaches to such terminii has practically forced a peculiarly limited application of "heavy electric traction" in the steam railway field.

The new and varied problems that have arisen have engaged the attention and received the most careful study from the foremost electrical engineers in the country, together with the steam railway officials whose systems are involved. In the course of this work much has been said and written upon this and related subjects, so that the questions involved have become more or less familiar to the reading railway man, whether steam or electric. In an effort to present something that possibly may have been overlooked and yet be of some present interest in connection with the "Heavy Traction Problem," the writer will point out some features that have been impressed upon him in elevated electric railway operation which may have a bearing on the subject under discussion.

The writer thinks it a safe statement that the elevated railways present the best example of systems, approaching heavy electric traction conditions, that have been operated for a sufficient period and on a large enough scale to give us good operating data, and show the results of standardization and thoroughly systematized management.

The interurban railways have made wonderful strides in the past few years, but the number of car equipments employed and the periods they have been in service have not given them the severe trying-out process of continued heavy use such as has been the case with the elevated railways.

Commencing with the Intramural Railway at the Columbian Exposition at Chicago in 1893, the Metropolitan West Side Elevated in 1895, followed by the Lake Street, the South Side Elevated, and the Northwestern Elevated, all in Chicago, and the Manhattan and Brooklyn Elevated, in New York City, and the Boston Elevated, in Boston, we follow through a period of thirteen years of successful practical daily performance of very severe service.

These elevated railway systems of Chicago, New York, Brooklyn and Boston, including the Interborough subway service, operated, in round figures, 170,000,000 car-miles, carried 685,000,000 passengers, and made gross earnings of about $34,300,000 during the year 1905.

This was accomplished with electrical equipments. The South Side and Oak Park lines, in Chicago, and the Manhattan and Brooklyn lines, in New York and Brooklyn, originally were run with steam engines, which, therefore, gives us a basis upon which to draw some interesting comparisons. Through the courtesy of the managers of these properties the writer is able to give data, in the tables on the next page, placing the roads in the order in which they were converted from steam to electric operation.

Under steam operation the Brooklyn Rapid Transit Company's records were kept in train-miles, and no estimate of cars per train at this date is reliable. Electric operation data is kept per car-mile, but the costs are so involved between the street car and elevated systems as to make an exact figure impossible to reach, the power for both systems being generated and distributed without means of separate measurement. Both kinds of equipments being operated on surface and elevated tracks, also makes the division of costs purely arbitrary. The general indications are, however, that the cost per car-mile is slightly less with electric than with steam, at the same time giving an increased schedule speed.

MANHATTAN—INTERBOROUGH (1905).

Including subway service.

Passenger cars	2,348
Motor cars	1,322
Total car miles	79,950,791
Passengers hauled	339,104,820

Schedule speeds: Elevated, 15 m. p. h.; subway local, 15 m. p. h.; express, 25 m. p. h.
Period of operation (subway), one year.

For later references and to complete the list, the following statistics are added for the roads originally equipped electrically:—

METROPOLITAN WEST SIDE ELEVATED RAILWAY (CHICAGO, YEAR OF 1905).

Passenger cars	420
Motor cars	158
Total car miles	11,352,358
Passengers hauled	46,186,753
Schedule speed, m. p. h.	15.4
Cost per car mile	$0.0931

Period of operation, ten years.

In all the cases "cost per car-mile" given is the total operating expenses for the road, not including taxes divided by the total car-mile. An examination of these figures for steam and electric service shows in every case a decreased cost per mile, an increase in schedule speeds, and a very large increase in traffic.

In considering the decrease in cost per mile with electric over steam operation in the above comparisons, the fact of the increased speed must be especially noted, as the higher rate of acceleration necessary to give the higher schedule speeds means a great increase in power consumption, so that the decreased cost shown on the face of the figures does not at all represent the true relative economy. As an example, the South Side Elevated Railroad, of Chicago, increased its schedule speed from 13.08 miles per hour to 14.95 miles per hour. This represents an increase in power required per car-mile of fully 30 per cent.

Even more marked is the increase on the Manhattan Elevated, where the actual running speed was 10.1 miles per hour under steam, and which has been raised to 15 miles per hour with electric operation, an increase in speed of 48.5 per cent. With a cost per car-mile of $0.095, the proportion chargeable to power will range in this class of service from $0.019 to $0.024, a little less than 25 per cent. of the total. By "cost of power" is meant the total operating expenses incurred in producing and delivering the current to the car. The maintenance of the motor equipment and kindred items will also quickly show the effects of changes in schedule speed, and must be considered in these comparisons.

For these reasons, had the speed not been increased above the steam schedules, when the change in motive power was made, the electrical equipment would have shown in some cases from 25 to 30 per cent. decrease, other conditions remaining stationary.

As the objection is sometimes made that the figures we are considering are derived from electric apparatus in use but a few years, and are being compared with old steam apparatus figures, let us examine the record of the Metropolitan West Side Elevated Railway, of Chicago, in operation electrically now for eleven and a half years, which stands, therefore, on a fairly equal footing with the other steam elevated equipments.

On the data sheet in Fig. 1 is shown the following:—

First. The curve giving the average passengers per day, plotted by months, except for the year 1905, which is shown for brevity by the daily average for the year.

Second. The average car-miles per day similarly plotted.

Third. The schedule speed in miles per hour. This is represented by a sloping line from 13.9 miles per hour in 1898 to 15.4 miles per hour in 1905. This method of representation was resorted to for simplicity, as the road, having four branches, which from time to time were extended, the schedules were changed so frequently that the facts could not be intelligibly shown in a single curve.

The main fact indicated, however, is that the schedule speed of 13.9 miles per hour early in the operation of the road has been raised by intermediate steps to 15.4. This does not include the speed on the Union loop, which is 10 miles per hour, and is considered as a downtown terminal for the elevated roads.

Fourth. The average cost per car-mile given by years. It will be seen that this, commencing in 1900 at $0.07151, increases gradually to $0.0971 in 1905, with the introduction of the multiple-unit system. This change to multiple-unit control involved the purchase of only fifty-five new motor equipments, raising the number of motor cars to 158. The service is still locomotive in type during sixteen of the twenty-four hours, two motor cars per train being in use only during the heavier periods of travel, the average cars per train throughout the year being less than three. It will be noticed that the rates per hour or per day paid to employees increased about 14 per cent., and the price of coal about 20 per cent. in the same period.

Here, then, is an electric system that has been in operation ten years, upon which the motors, rolling stock, track system, etc., have developed a practically constant maintenance charge. That this road, making a schedule speed of over 15 miles an hour should now be show-

OAK PARK & CHICAGO ELEVATED RAILROAD.

	Steam Year of 1895.	Electric Year of 1904.	Increase per cent
Passenger cars	100	123 (includes motors).	
Locomotives	35	42 (motor cars).	
Total car miles	2,721,965	4,550,799	
Total passengers hauled	9,936,450	16,005,328	
Passengers per car mile	3.65	3.52 (dec.)	3.6
Passengers per car mile per annum	99,364	130,124	23
Cost per car mile	$0.1174	$0.1078 (dec.)	8.2
Schedule speed, m. p. h	12.5	15	22

Period of electric operation, eight years.

SOUTH SIDE ELEVATED RAILROAD (CHICAGO).

	Steam Year of 1894.	Electric Year of 1905.	Increase per cent.
Passenger cars	110	254	
Locomotives	31	196 (all motors).	
Total car miles	5,182,598	8,230,415	
Total passengers hauled	13,587,791	32,959,752	
Passengers per car mile	2.62	4.00	52.6
Passengers per car mile per annum	123,525	129,762	5
Cost per car mile	$0.106	$0.089 (dec.)	16
Schedule speed, m. p. h	13.08	14.95	14.3

Period of electric operation, seven years.

BROOKLYN RAPID TRANSIT (ELEVATED DIVISION, BROOKLYN).

	Steam Year of 1898.	Electric Year of 1905.	Increase per cent.
Passenger cars	430	1,002 (includes motors).	
Locomotives	139	558 (motor cars).	
Total train miles	5,158,365	22,407,331 (car miles).	
Total passengers hauled	44,170,810	122,166,540	
Passengers per car mile	....	5.2	
Passengers per car mile per annum	102,723	121,922	18.7
Schedule speeds, m. p. h	11.5	15.8	37
Cost per train mile	$0.384	Cost per car mile.	

Period of electric operating, six years.

MANHATTAN ELEVATED RAILROAD (NEW YORK).

	Steam Year of 1901.	Electric Year of 1904.	Increase per cent.
Passenger cars	1,122	1,356 (includes motors).	
Locomotives	334	833 (motors).	
Total car miles	43,860,158	61,743,000	40
Passengers hauled	190,045,741	286,634,000	50
Passengers per car mile	4.34	4.65	7.15
Passengers per car mile per annum	169,381	211,382	24.8
Cost per car mile	$0.1198	$0.095 (dec.)	20.4
Schedule speed, m. p. h	10.1	15	48.5

Period of electric operation, three years, ing, in its tenth year of operation, $0.0931 per car-mile, is a very reasonable argument for the economy and durability of an electrically equipped system.

Referring again to the comparative figures on electric railroads that have changed their form of motive power, we find increases in earnings per mile per car per annum, etc., all of which point to the greater earning capacity of the electric car unit. This greater earning capacity is shown to be due, in the systems we are considering, to higher schedule speed along the line and the shorter intervals between train units, made possible at junctions and terminals. As examples of these features, take the following:—

The New York terminal of the Brooklyn Bridge depended originally upon steam locomotives for its operation. Cars were hauled by cable across the bridge and then switched at each end by steam locomotives. The service proved inadequate, and upon electric motors being installed under the bridge cars, the locomotive system was done away with, and a remodeling of the track system was made possible, which resulted in doubling the capacity in cars per hour.

On the Manhattan Elevated system all the Ninth avenue trains and the Sixth avenue trains which run north of Fifty-ninth street pass through the junction at Ninth avenue and Fifty-third street. These tracks, two local and one express, lie north and south on Ninth avenue, and two turn east in Fifty-third street to join the Sixth avenue line. The capacity of this crossing, therefore, controlled the amount of service it was possible to give on the west half of the Manhattan system.

The north-bound tracks on Ninth avenue, approaching from the south, have an ascending grade of 107 feet to the mile. Through this junction steam trains of five cars were scheduled to operate at intervals of from 55 seconds to 1 minute and 10 seconds during the rush hours, but blocks were so frequent on account of the locomotives stalling on the up-grade in the evening rush as to make the service very unreliable.

The length of interval was largely controlled by the necessity of holding the train back almost at Fifty-first street until the route was clear, in order that the steam engine might be sure of getting up the grade. With electric equipment, trains of seven cars run right up to the target at the crossing and stop with impunity on the grade, the regular rush hour operation now requiring a train movement every 33 seconds as a minimum, which is accomplished with regularity and precision, and blockades are things of the past.

On the two-track stub terminal at the City Hall station, Manhattan Elevated trains now operate on intervals of 1 minute and 40 seconds.

In general terms, the irregularity at junction points, congestion at terminals, and the limitations in speed of the locomotives on the Manhattan Elevated have caused the system to reach its maximum usefulness, the largest regular day's traffic being 852,000 passengers, and the total traffic for the last years of steam operation actually showing a continual decrease. With the introduction of electric service, the maximum traffic, without adding a foot of track, jumped to 1,076,000 passengers as the largest regular day's business, an increase over the best showing of steam of more than 26 per cent.

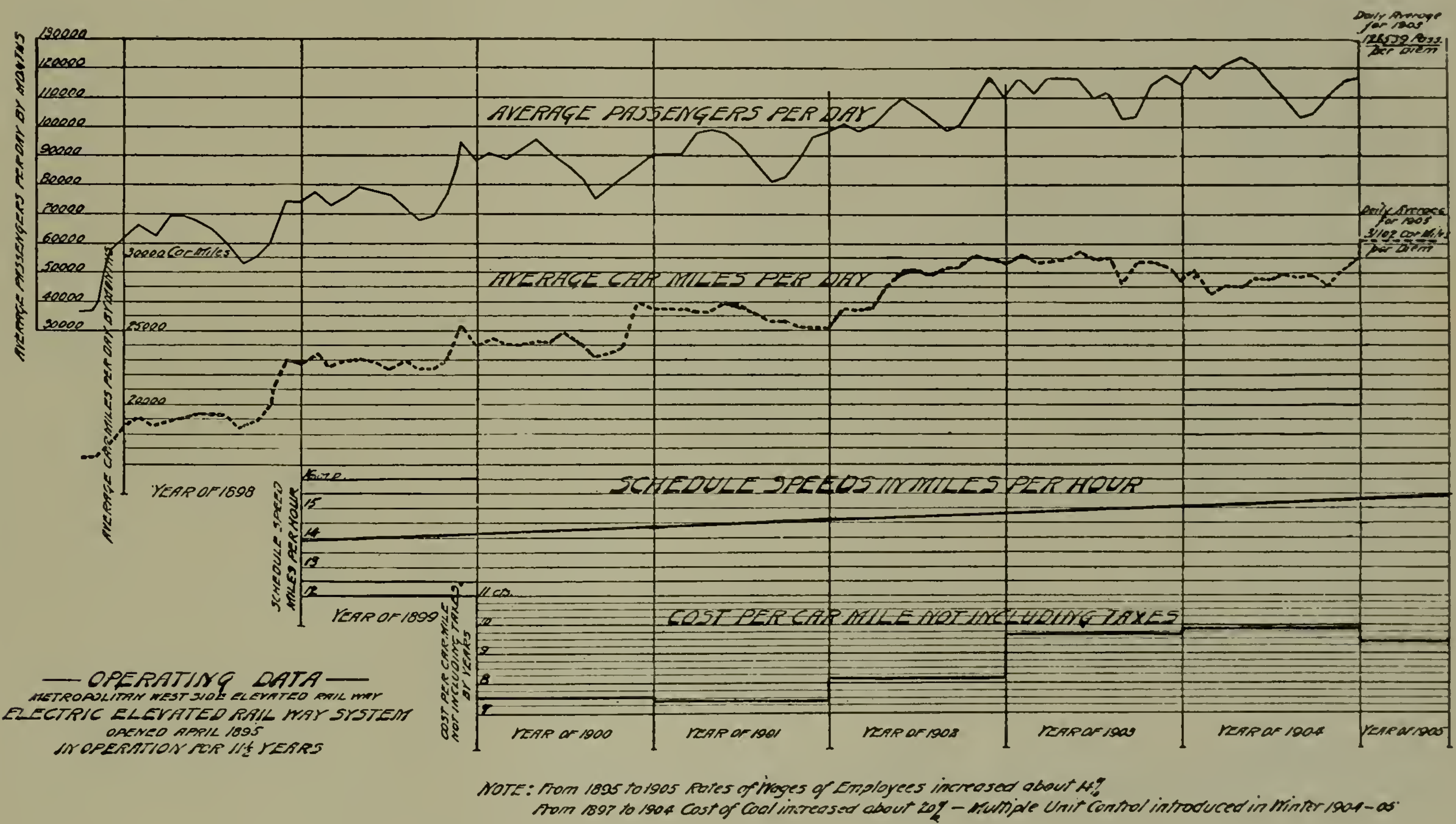


FIG. I.—DATA SHEET SHOWING PASSENGERS, CAR MILES, SCHEDULE SPEED, AND COSTS

The large increase on the other systems will be readily noted. These results, however, are complicated in some cases by reason of increased trackage having been put in operation, and, therefore, not making so striking a comparison as the Manhattan Elevated in New York. Enough has been shown, however, to warrant the claim for a greatly increased capacity by equipping these systems electrically.

Let us dwell a moment longer on the frequency of service by showing what is the daily routine on the Union Elevated loop in Chicago.

Referring to the diagram, it will be seen that the "loop" is a double-track line two miles in length, located on Van Buren street, Wabash avenue, Lake street and Fifth avenue, a rectangle surrounding the business and shopping section of Chicago. On the inner track run the trains of the Metropolitan and South Side Elevated roads, and on the outer track, in the reverse direction, run those of the Northwestern and the Chicago and Oak Park Elevated lines. This requires a crossing at grade of the traffic of the various roads. At the southwest corner of the loop (Fifth avenue and Van Buren street) the Metropolitan trains enter and leave, passing to and from their own tracks to the inner track of the Union loop. The Northwestern and Oak Park trains cross the outgoing and incoming tracks of the Metropolitan, and South Side trains occupy the inner curve when passing from Fifth avenue to Van Buren street.

To obtain the greatest capacity, incoming and outgoing Metropolitan trains move simultaneously through this junction, and similarly South Side and Northwestern and Oak Park trains are handled by one movement.

This results in the following train movements on every week day, Sunday being somewhat lighter.

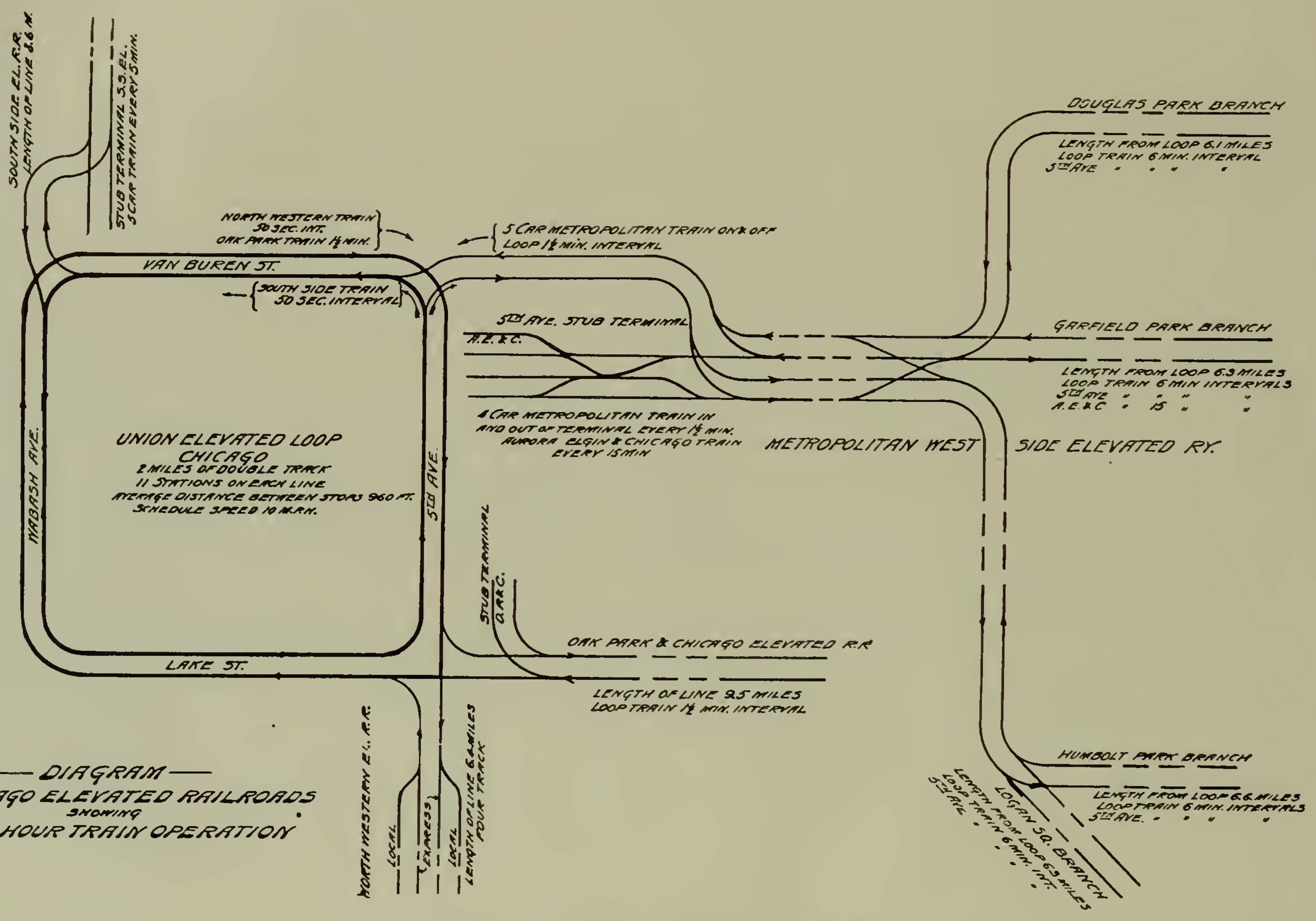


FIG. 2.—DIAGRAM OF THE UNION ELEVATED LOOP IN CHICAGO

TRAIN MOVEMENTS—METROPOLITAN JUNCTION, UNION LOOP, CHICAGO

During twenty-four hours 1776 trains are handled, averaging one every 49 seconds.

During two hours, 4.30 to 6.30 P. M., 263 trains are handled, averaging one every 27½ seconds.

During one hour, 5 to 6 P. M., 163 trains, averaging one every 22 seconds.

During 15 minutes, A. M., rush, 75 trains, averaging one every 12 seconds.

The South Side junction, at Van Buren and Wabash avenues, is simultaneously handling substantially the same train movements. During rush hours practically all the trains consist of five cars, there being only a few of four cars.

When one stops to consider that this is not a single isolated performance, but the daily week-day routine, and that these rush hours, from which the above congested periods are taken, occur twice each day, it gives a good idea of the precision and regularity with which electrically equipped trains can be handled.

Follow this matter a little further in detail, and note what is exacted from this set of train units above the mere promptness with which they pass this point in the system.

Referring to our map, we will note that the Union loop receives the trains of four distinct elevated railway lines. Now, in order that this junction shall operate smoothly, the trains must be at their targets ready to move instantly when given the signal. They cannot be lined up in a row to insure this condition, otherwise the passengers will be delayed and dissatisfaction ensue. The running time cannot be lengthened out so that the motorman can loaf along and bring his train to this point with ease, for the street car competition is severe, and the time must be cut to a minimum. The various roads maintain on their own lines during the rush hours schedules of from 14½ to 15½ miles per hour, including stops. It takes practically the entire equipment of the road to fill the rush hour schedules, so that running out gap-trains is not generally possible.

Here, then, we find trains of five cars passing through this junction "on time," delivering or receiving their heavy load, returning to their outer terminals and again returning a second time in the same rush hour period and "on time." Add to this that the Northwestern runs express and local trains, making entirely different runs on separate tracks after leaving the loop. The South Side runs trains into its Congress street stub terminal. The Lake Street runs also into its Market street stub, and further, the Metropolitan has four distinct branches, from each of which is run not only the loop trains, but an equal number of Fifth avenue trains, leaving the outer terminals alternately with loop trains, and running into the Fifth avenue terminal.

The Metropolitan loop and Fifth Avenue sets of trains each run on a $1\frac{1}{2}$-minute interval, the Fifth avenue terminal also accommodating the interurban trains of the Aurora, Elgin & Chicago road on a 15-minute interval during the rush, those passing over the Garfield Park line to the city limits. That such a complication and frequency is in itself desirable the writer does not pretend to claim, but that it is a demonstrated operative fact is undeniable.

The amount of service exacted of the equipments of these roads is also interesting, it being a fact that practically all of the motor cars on the Metropolitan Elevated, for example, except those in the paint shop or in the general repair shop for general overhauling, are in service every rush hour. This is accomplished by arranging for the inspection of other than rush hours, and by the use of extra motor trucks, which are interchangeable.

Some of these cars, of course, make only two trips each rush hour, but they are ready for further use if required. The total mileage on the Metropolitan Elevated for 1905 shows an average of 24,740 car-miles run per car (motor and coach) per annum, which, considering that 50 per cent. of the passengers are handled in four hours of the day, shows a high degree of "availability for service."

A detailed record of 105 Metropolitan Elevated motor cars, which made over 3500 miles per month each during the twelve months from May 31, 1905, to June 1, 1906, shows that the general periodic overhauling, the regular inspection of terminals, and time in shop for repairs to the electrical apparatus, running gear, air brakes, and all parts of the equipment, calculated in hours, amounted to less than 3 per cent. of the time. In other words, these cars which did the heavy work during the year 1905-1906 were available for service on the elevated road ninety-seven per cent. of the time.

To accomplish this service the following method of inspection is used:—

Motor cars are inspected at terminal shops every 600 miles; this takes one hour per car.

Cars are given general overhauling of motors and control every thirteen months; this takes generally two days.

Motor cars average generally on this road 4500 miles per month.

Generally speaking, the statistics for steam locomotive service indicate that from 8 to 12 per cent. of the time out of service represents a high state of efficiency, while on some roads 25 per cent. of the time "in shop," or an "availability for service," of 75 per cent. is nearer the figure for locomotives making a mileage comparable with electric motor mileage of 4500 miles per month, which we have been considering.

It is true that the elevated service, on account of its short intervals between trains, its frequent stops and comparatively light train units, presents an ideal field for electric operation; nevertheless the extent and period of constant service these systems have gone through brings out some advantages which are interesting in connection with recent and proposed heavy electric traction developments. We may say that consideration of the records and results of elevated electric operation, aside from the much argued question of economy, shows clearly the three following advantages over steam operation:—

1. An increased capacity per car unit, due to greater "availability for service" and higher schedule speed.

2. An increased capacity for the system in general, due to shorter intervals possible at terminals and junction points, abolishing of relays, and general facility for handling at stops and in yards.

3. An increased earning capacity, due to 1 and 2, and to more attractive service by reason of greater frequency of trains possible with economy, a cleaner and quieter service, etc., giving returns in larger proportion than the direct ratio of apparent increased facilities.

In regard to the results to be obtained by substitution of electric for steam apparatus under somewhat similar conditions on the larger steam railway system, we might reasonably expect to realize the first item, as it is inherent in the nature of the apparatus when its use has been developed to meet the local conditions. This is amply demonstrated, not only by the examples here given, but by the performance of electric railway equipments generally.

The second item is illustrated by what we have seen is being done daily on the greatly congested elevated systems, where such service would be impossible with locomotives. This forms, the writer believes, one of the strongest arguments for the new power, that is, the possibility of increasing the capacity of large city termini with electric service. Where real estate values are so enormous and the physical difficulties for enlargement of the terminals so great, the increased capacity of the existing site that it is possible to obtain with electricity is worthy of serious consideration.

Given a large city terminal, surrounded with expensive buildings or possibly bounded by important city streets, and which has reached its maximum train capacity with steam operation, and we are confronted with enormous expenditures to materially increase the capacity with the old motive power.

With the electric equipment the absence of smoke allows of double-decking, as is being done in the New York Central station in New York. The necessity for a local coal and water supply, round-house, etc., is done away with. The hauling of passenger trains with multiple-unit control, which eliminates relay switching engines and adds to the flexibility and ease of handling the units generally, effects an increase in the passenger capacity that could not be obtained with steam without abandoning the existing location or entering into purchases and street-closing proceedings that would prove prohibitive in every way.

The third item is one only just being realized in its true extent by railway men. It is a curious fact that electric service actually seems to create business; not only do we see this illustrated in the elevated systems we have been considering, but in interurban work as well. An electric line has often been known to run through a series of towns paralleling a steam railroad, and develop a traffic largely exceeding that lost by the local steam line, this additional business being apparently created without increase of population, and due to the more frequent and convenient service.

It is a peculiar fact that the American citizen is essentially restless and impatient, and, given two competitive systems, he will take that offering the most frequent service, even at a little expenditure of time

He does not want to wait. He prefers to keep moving. Again, trains run on even fractions of an hour are more attractive to him than those run irregularly; he is impatient of time tables; he will not hunt through the A. M.'s and P. M.'s of a steam railroad time table when he knows that every hour, half, or quarter hour there is an electric car.

All of these items are at the basis of the successful inroads made upon steam railroad passenger traffic by the electric lines, and the writer suggests that what has been found true of passengers may in a degree be found true of local freight business as well. Is it not possible that a modification of present steam railway methods may be found profitable in the handling of freight where it has to be hauled with electric traction?

Economy and efficiency in steam railway practice point to constantly increasing size of train units. The lessons of electric operation are just the reverse.

The physical drawbacks involved in steam operation of the large railroad terminals were primarily instrumental in clinching the arguments for "heavy electric traction" for terminal operation. That this system when once introduced in even this limited form will extend to main line work seems certain. That we shall see radical changes in steam railway methods in yarding and despatching trains, in reduction in size and increase in number of train units, will, the writer believes, follow as an inevitable result of the application of electricity to steam railway operation.

Relative Economy of Steam Turbines and Engines at Varying Percentages of Rating

By WALTER GOODENOUGH

A Paper Read at the Convention of the American Street & Interurban Railway Engineering Association

IT has become evident, from time to time, that what is needed in the power station is not so much more economical prime movers, but rather more intensive operation of the particular type of machinery which we now have.

The assumption that fixed charges are spread over the whole twenty-four hours, and that the machine operates during the full twenty-four hours is, of course, not correct; but in the present instance, where it is desired to bring out rather the effect of the combination of fuel and fixed charge costs, instead of actual operating costs, this assumption is considered to be well taken. On this basis characteristic curves for engine-driven and turbine-driven units are produced.

It is assumed for the purpose of this paper that each plant is of one unit running twenty-four hours per day, and on this basis fuel costs and fixed charges per kilowatt-hour are plotted individually and then combined. No other costs have been taken into consideration, as the addition or subtraction of such constant costs as labour, heat losses, etc., makes little or no difference in the characteristics of the curves until these increases or decreases have assumed a very large size.

It is further assumed that the labour costs for a single engine-driven unit will be fully as low as for a turbine, and this assumption has also been made for the maintenance of the respective machines. It is taken also that the extra heat turned into the feed-water by turbine auxilaries over those of engine auxilaries will offset the greater amount of heat used in the work of driving the larger turbine auxiliaries.

In making the curve of fuel cost, the price of coal is assumed at $2 per ton, and the evaporation per pound of coal as seven and one-half pounds of water. On this basis, 1000 pounds of water evaporated will cost 13½ cents.

In determining the fixed charges, the following percentages have been taken for engine-driven units: Interest, 5 per cent.; depreciation, 12 per cent.; maintenance, 1 per cent.; taxes, 1 per cent.; total, 19 per cent.

For the same charges for turbine-driven units the percentages have been taken: Interest, 5 per cent.; depreciation, 10 per cent.; maintenance, 1 per cent.; taxes, 1 per cent.; total, 17 per cent.

In the above tabulation interest remains standard at 5 per cent.; the maintenance remains the same for both turbine and engine, as any good engine unit will not have a higher maintenance of itself and its auxiliaries than a turbine with its much more numerous auxiliaries. In considering depreciation, amortization has been neglected, and the depreciation deliberately placed high.

In the present state of the art we can expect to see developed in the near future prime movers and fluid generators (including the pieces of apparatus now known as boilers and gas producers) of such an increased efficiency that it will become necessary, for many reasons, to abandon our present units within a few years. We are assured by the makers of turbines that they are still exploring the field, and most of us have visions of high economy gas-driven machinery at no distant date.

So unsettled are the conceptions for the future of commercial economy in power generation that it cannot be but wise to place a high depreciation on our present machinery. Competition, local disturbances through municipal ownership, agitation and other commercial reasons will demand more than ever the supersedence of present-day designs for new ones of higher efficiency. The exact form in which "depreciation" is applied does not matter, the basic fact remains that machinery does depreciate, and the fact is not less true that the genus "stockholder" pays the depreciation. He may do it by default of dividends, held in a sinking fund by a careful administration, or by means of assessments, or interest on mortgages or bonds.

In regard to the first cost of the machinery under discussion, it has been assumed that with the 500-KW. units the system in use will be 500 volts direct current. It is also assumed that the engine units will have direct-current generators, and the turbine units alternating-current generators, requiring converting apparatus. It is further assumed that the engine will work with saturated steam, and that the turbine will use superheated steam. We, therefore, assume the following costs for the engine unit: Engine and generator, $45 per kilowatt; condensing apparatus, $4; foundations, $3; total, $52 per kilowatt. On the same basis we assume that the turbine with saturated steam would cost as follows: Turbine and generator, $36 per kilowatt; condensing apparatus, $6; foundation, $1; motor-generator apparatus and switchboard, $22; total, $65 per kilowatt.

In order, however, that full operating value from the standpoint of steam economy may be obtained from the turbine, it is necessary to install with our boilers some superheaters, and for this additional cost we should apply $4.25 per kilowatt, making a grand total for the turbine of $69.25.

In order to show the effect upon the combined kilowatt-hour cost of having to add converting apparatus, Curve "*D*," in Fig. 1, has been made, based on a total first cost of $69.25, less $22.

For 1500-KW. units it has been assumed that both the engine-driven and turbine-driven unit will generate alternating current, and on this basis there have been assumed the following costs: Engine and generator, $35 per kilowatt; condensing apparatus, $2.25; foundations, $2.25; total, $39.50 per kilowatt. On the same basis as the above we have: Turbine and generator, $28; condensing apparatus, $5; foundations, 50 cents; superheater and piping, $4; total, $37.50 per kilowatt.

In the case of curves for 1500-KW. units, it has been assumed, without question, that the engine will run with saturated steam and the turbine with superheated steam.

On the basis of all-size units, operating alternating current, the 500-KW. turbine makes quite a little better showing of rated load efficiency against the engine unit than the 1500-KW. size. The author would, however, suggest that the 1500-KW. unit is probably the one size where conditions of total cost per kilowatt, fuel and fixed charges come nearest those of the engine. For all sizes above 1500 KW. the combined cost of the turbine unit draws rapidly away from the engine unit in the direction of lower cost, and it might be suggested here that if there were any one spot where engine builders desired particularly to apply refinements to their designs in the way of larger cylinder ratios, rejacketing, reheating and superheating, the 1500-KW. size would undoubtedly prove the most fruitful for them. There is some question, however, as to whether the increased economies in steam consumption they might obtain would overcome the increased fixed charge cost due to greater expenditure to obtain these results.

As stated in the first part of this paper, it is of considerably greater importance in the immediate present to the station manager to consider how he may obtain the greatest economy from the units which he has, rather than where he can buy units having half a pound better steam consumption than what he has.

If we look at Fig. 1, it will be noted that the fuel cost for the 500-KW. engine unit is at its lowest point at 90 per cent. rating, while with the turbine unit this best fuel cost comes near to the 120 per cent. rating, both with and without superheat. Now, if we add to this the fixed charges per kilowatt-hour, we see in our engine unit that the point of maximum economy is moved from 90 per cent. rating to 125 per cent. rating. Also, in our turbine units the point of maximum economy, when converting apparatus is included, is moved up to about 145 per cent. rating from 120 per cent. When the converting apparatus fixed charge is not included, we find the high point of total economy has dropped back to around 140 per cent.

From these characteristic curves, therefore, it becomes quite apparent that we cannot carry our steady loads per unit any too near 100 per cent. rating. It would not, of course, appeal to the average careful station manager to operate his individual units at continuous loads above 100 per cent. Consideration has to be taken of the ability of the generator to stand continuous overload, and a margin has also to be provided for suddenly applied overloads or swings. It would seem, however, that there should be no valid excuse in a well-managed plant for not maintaining the loads as near as possible to 100 per cent. rating of each individul machine.

It is well known that engine builders have, for quite a number of years, built their machinery, for point of maximum economy, nearer to 75 per cent. rating than 100 per cent. rating, they assuming that the loads in a station would always be under, rather than up to or over 100 per cent.; and, therefore, they have put their machinery where it would show up the best under loads which the average engineer feels he can run. It is apparent, however, from these curves that the true economy of the plant is by no means the steam economy of the plant, and it is also seen that the engine builder, on the basis of steam economy alone, did not shove his point of best economy far enough back, after all.

On the other hand, it appears that the turbine builder has not yet reached consideration of this point, and he is building his turbine for a rating which carries the point of combined economy to considerably over 100 per cent. rating and close up to the point where the total economy begins to fall off sharply, and the capacity of the machine is be-

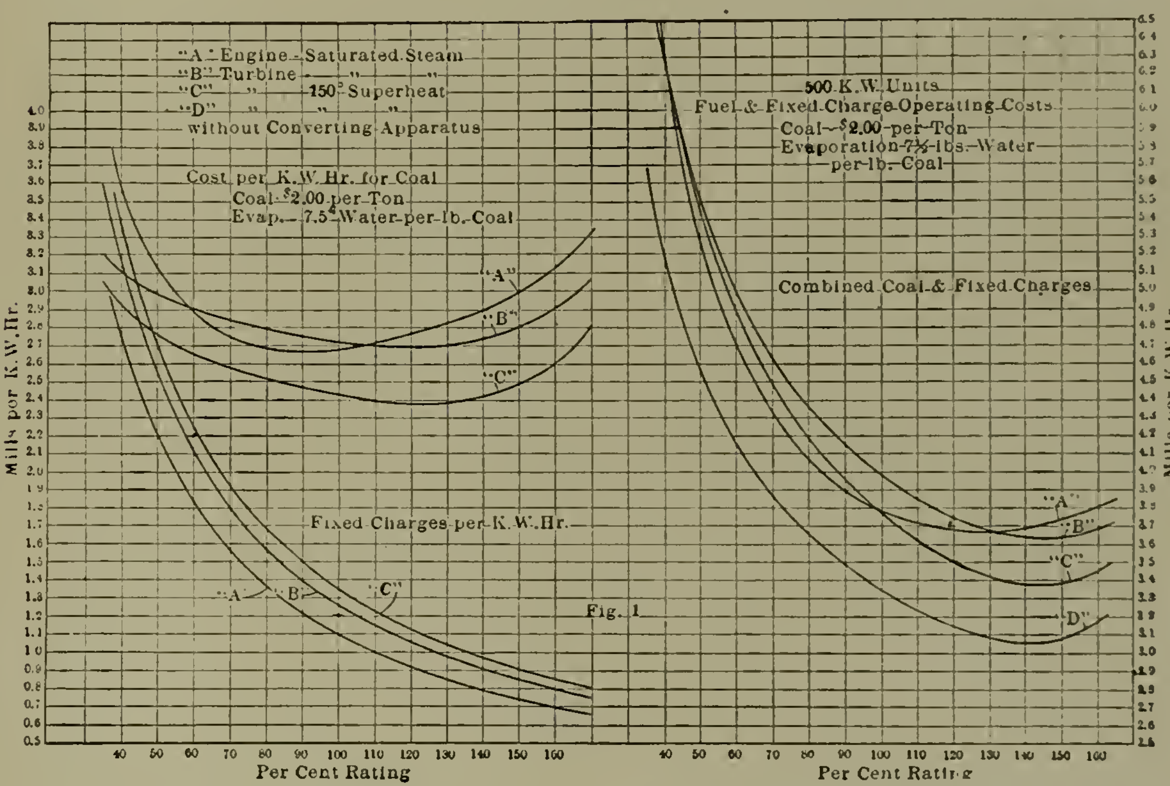


FIG. 1.—FUEL AND FIXED CHARGE OPERATING COSTS OF A 500-KW. RECIPROCATING ENGINE UNIT AND A STEAM TURBINE UNIT OF THE SAME CAPACITY

ing rapidly absorbed. In the particular instance of the 500-KW. units, it would seem that the engine overload capacity was not too far in excess of its generator capacity; but in the case of turbine it is apparent that the size of the turbine for the same size generator should be considerably decreased and means taken to insure, after such decrease, that overloads can be readily carried by the machine. Such changes as those would then bring the point of maximum total economy back to the place where it is actually possible to operate the machines under steady loads in the average power station furnishing current for a street railway.

However, the turbine builder has not supplied us with this very desirable machine, and it, therefore, becomes necessary for us to make the best of what we have. It would seem wise to fix as high as possible the loads at which each individual machine in the station should operate, and then maintain these loads as continuously as possible. When variations have to be taken they should naturally be taken by increasing the load on the machines already in service, rather than to put in another unit and underload it, or all of the units in service. There is a question of reliability and safety of service which comes in here, and which the station manager will, of course, have to settle according to the character of his load and the number and size of his units.

The foregoing naturally brings up the question of selection of the size of units in new developments or renewals. The end of all construction should be the minimum combined cost per kilowatt-hour of operation, and, therefore, it behooves us in selecting our new units that we study carefully not only the immediate loads to be applied, but also the expected future loads. It is to be suggested that many managers can, with good success, chart their daily load and fix almost precisely, from day to day, the time when each unit shall enter upon its work and the load which it shall carry.

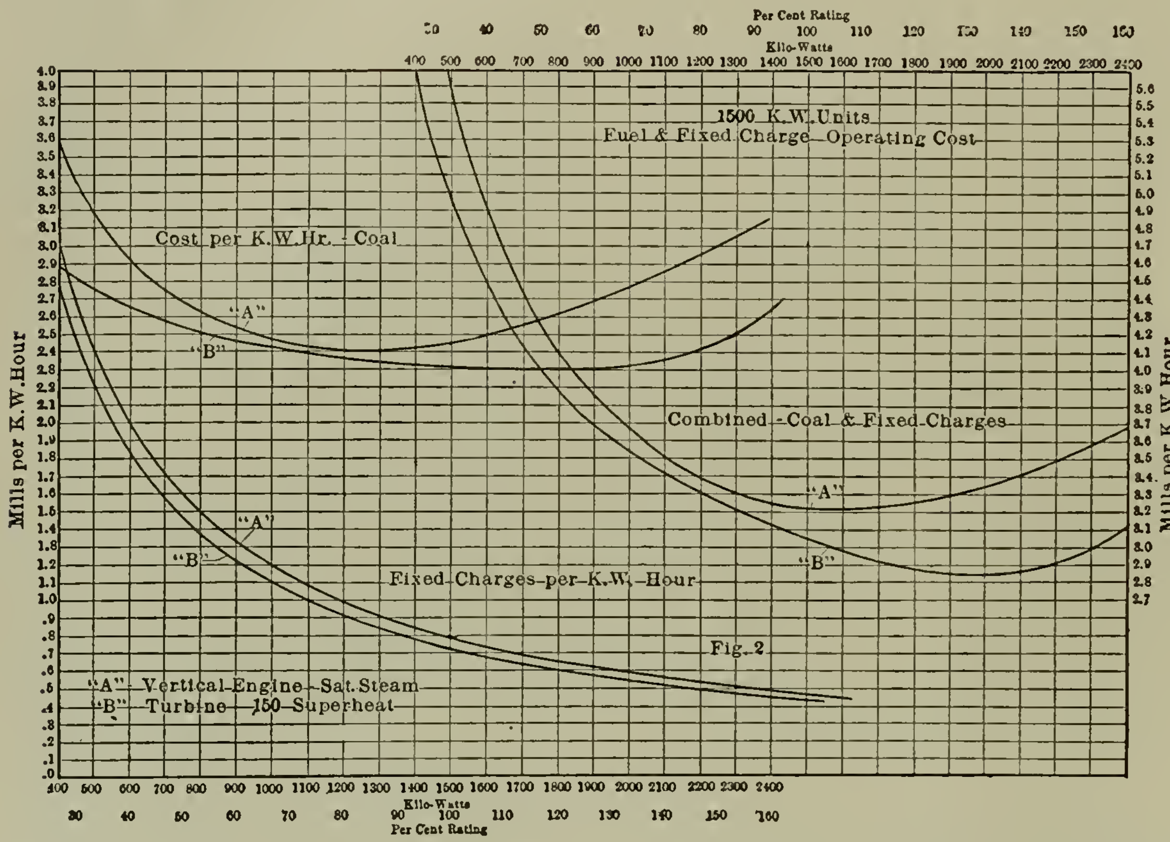


FIG. 2.—FUEL AND FIXED CHARGE OPERATING COSTS OF A 1500-KW. RECIPROCATING ENGINE UNIT AND A STEAM TURBINE UNIT OF THE SAME CAPACITY

The average station engineer has too limited a view, from reasons of training, to take any initiative of this sort. He will often require considerable persuasion to get him over the fear of running his machinery too hard. It is the author's general experience, however, that with some one to start such a man authoritatively along the lines of better economy, that he becomes, not only anxious to make a better showing, but his pride in such a showing is very marked.

The general statement which has been made that turbines have a flatter load curve than engines is decidedly misleading when considered from the standpoint of total cost per kilowatt-hour. Inspection of the combined curves on both Figs. 1 and 2 show that at 100 per cent. rating the rate of change in cost per kilowatt-hour of operating the turbine is decidedly greater than for the engine. It is seen from this curve that the engine, with its point of steam economy at 85 or 90 per cent. rating, has at 100 per cent. rating a much flatter curve of total economy.

If we will inspect Curve "*D*," Fig. 1, we will see that for an increase in load, from 75 to 100 per cent. rating, the increase in economy on the basis on which this curve is made will be 11 per cent. Of this 11 per cent. gain in total cost the steam economy gain is only 47 per cent., while the fixed charge gain is 23 per cent., or four times as much gain as in steam cost. These percentages, of course, will bear quite some changing under different conditions; but it must be borne in mind that the characteristics of the curves will remain very generally the same.

Again, as stated in the first part of the paper, it is not strictly correct to assume that the unit is to run twenty-four hours a day at a certain load. However, it should be noted that applying the fixed charges to the unit for the actual number of hours run each day will increase these fixed charges per kilowatt-hour, and more than ever increase its effect on the total combined economy, showing the point of maximum economy still further up into the overloads. The decreasing of the fixed charges per kilowatt-hour means, however, an increasing of the steepness of the fixed charge curve below 100 per cent. rating, thereby accentuating from the other standpoint the marked effect upon total costs which fixed charges have at all ratings below 100 per cent. or thereabouts.

The effect of the increase in the cost of coal, while not affecting the strict character of the curve of cost per kilowatt-hour, does somewhat flatten out the inclined portions of the curve.

Thus it may be truthfully said that the curves "*A*," "*B*," "*C*" and "*D*" will at all times retain their characteristic forms, and that being the case, whatever has been shown in this paper as to relative costs for different percentages of full load is very closely true. The increase or decrease of either fuel cost or fixed charge cost changes but very slightly the relation of the individual fuel and fixed charge curves to the combined curve.

The point has been raised that, after a plant is once installed, the fixed charges do not enter into the economy of operation, and that, therefore, the plant should be run at its lowest steam consumption. If, however, it is legitimate and necessary to figure fixed charges per kilowatt-hour in preliminary estimates, it appears to the author that they should be considered when the plant is in operation, for two reasons:—

First, the operating reason, that with the load usually carried by the operating engineer, full value is not being obtained from the investment. A monthly report which shows fixed charges per kilowatt-hour generated should be of immense value to the operating superintendent in determining whether his plant is receiving the particular and discriminating attention which such a large investment warrants.

Second, the investment reason, that a machine which has the lowest combined cost per kilowatt-hour at the individual loading that is carried, is the most desirable to continue in the installation. Manifestly a machine which has a combined kilowatt-hour cost lowest at 100 per cent. rating is better than one having its lowest cost at 140 per cent. rating.

The first machine will probably have a smaller steam end for the same generator than the second unit. By adding automatic overload devices, costing little money, to the first machine, it can be made to operate up to the full overload capacity of the generator in taking care of those peaks in the load which are of short duration.

The author would point out that this is not a consideration of station load factors, but rather a consideration of the economy in operation of individual units, and also economy in their selection as affected by type and design.

In conclusion, the author would additionally point out that the gains indicated herein for turbine and engines are, to a greater or less extent, true for all other station apparatus, and perhaps no more true than in the case of boilers whose load and operation seem equally as far buried under misapprehension as are the generating units.

Brief Topics of the Month

Deposits of ore containing tantalum have been discovered at Henryton, near Baltimore. The ore is found in crystalline form embedded in felspar, and yields, on analysis, 38.19 per cent. of oxide of tantalum, and 13.21 per cent. of oxide of niobium.

The world's net consumption of rubber in 1904 was 57,300 tons, of which 26,470 went to the United States, 12,800 to Germany, 10,030 to England, 4130 to France, 1320 to Austria-Hungary, 1218 to Holland, 748 to Belgium, and 588 to Italy. According to the Mouvement Géographique, of Brussels, the world's production will reach 75,000 tons this year. Its value is estimated at $115,800,000.

Experiments with a submarine telephone line are now being carried on at Lake Constance. The cable is about seven miles long, and reaches a maximum depth of 820 feet below the surface. It connects Friedrichshafen, Germany, with Wurtemberg and Romanshorn, Switzerland, and was constructed according to Prof. Pupin's long-distance system.

According to figures gathered by the Chicago City Railway Company, car heating by electricity possesses many advantages over hot-water heating. The data obtained were as follows:—Weight of heaters: hot water, 1454 pounds; electric, 360 pounds. Price of heaters per car: hot water, $140; electric, $80. Repairs per day: hot water, 10 cents per car; electric, 5 cents. Attendance on hot water heaters, 10 cents per car per day. The electric heaters used 12 amperes at 500 volts for nine hours, a total of 54 kilowatt-hours per car per day. This is figured at a cost of 0.992 cent per unit of power. Figuring up the total maintenance and fixed charges cost, the hot-water system was found to be 80 cents per car per day, and the electric 73 cents.

According to the Bulletin of the New York Edison Company, the electric equipment of Manhattan Island continues to grow at an increasing rate. During the twelve months ending August 31 the net increase is 9566 consumers, having an aggregate installation of 866,400 16-candle-power equivalents. One hundred and twenty-eight thousand three hundred and ninety-nine horsepower in Edison motors are now used, and the installations, all taken together, aggregate 4,319,261 equivalents of 16 candles.

In the June number of The Electrical Age, it will be remembered, A. J. Rossi spoke of the possibility of the electric smelting of the magnetite iron ore on the Pacific Coast. This possibility is soon to become a fact, as the Northern California Power Company, in conjunction with the Shasta Iron Company, is to conduct a series of trials of the Héroult process similar to those recently made in Canada. R. A. Turnbull, who participated in the smelting experiments at Sault Ste. Marie, and who is now Dr. Héroult's representative in Canada, is at present in charge of the engineering side of the undertaking. M. Petinot, who has been connected with Dr. Héroult's electric smelting plants in Europe, will be in charge of the work at the spot.

The Dayton Lighting Company, of Dayton, Ohio, has announced that Nernst lamps will be furnished free in the alternating-current district and gem lamps in the direct-current district. They will be maintained as the ordinary filament lamps have been.

According to a report of the British Foreign Office, the Japanese imports of electric motors in 1905 were valued at $838,995. In 1904 they were $475,995. Among the principal items of import at the port of Yokohama were 7368 tons of telegraph wire, valued at $372,345. The value of the electric light apparatus imported was $195,910, as against $147,615 in 1904. Of electric light wire, $334,850 worth was imported in 1905. In 1904 the value of the imports was $325,385. Submarine and underground telegraph cables showed a decrease. Nearly all these imports, with the exception of the submarine cables, were sent from the United States and Germany.

Fires caused electrically during the last three months were seventy-four in number and resulted in $161,000 loss, according to a report of the National Board of Fire Underwriters. Eight were due to the crossing of high-tension wires with telephone and lighting circuits, nine were due to the grounding of lighting and motor circuits, and thirty-one were due to short circuits on interior wiring.

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Leading Articles

Wireless Receivers: The Audion

So many and various have been the devices that within the past eight or ten years have been shown to be responsive to Hertzian waves, that the announcement of a new wireless receiver, however seemingly novel, scarcely excites any surprise.

It is nevertheless interesting to note that, with perhaps the exception of the Branly coherer, the operation of these receivers is based upon the peculiar action of Hertzian oscillations upon hitherto more or less well-known phenomena. For example, the different magnetic detectors that have been introduced into wireless practice have availed of the Rutherford equipment, in which electric oscillation causes demagnetization of steel needles previously magnetized to saturation. Rutherford's experiment in turn appears to have been instigated by Henry's well-known experiments of 1842, as a result of which he suggested the oscillatory character of an electric discharge.

The fine wire electrolytic receiver, or polariphone, as it is also termed, is based upon the polarization of a voltaic cell to a point at which the Hertzian oscillations readily break down the polarization, thereby varying the current in the circuit. Certain people have found an anticipation of this device in Woolaston's fine wire experiments of 1801, described in "The Philosophical Magazine" of that year. M. Ferrie is also mentioned as having suggested this detector, while others give the credit to Dr. Pupin by reason of his work with the electrolytic rectifier.

The audion, the wireless receiver which Dr. De Forest described in his recent paper before the American Institute of Electrical Engineers, which is printed elsewhere in this issue, is not an exception to the rule that has been mentioned. In its present form it appears to be based on the Elster and Geitel tube for showing ionization of a gas, or the electrification of a platinum plate, by means of an incandescent filament, which device, as Dr. De Forest points out in his paper, Fleming has utilized for the rectification of Hertzian oscillations. To the Fleming modification of the Elster and Geitel tube or bulb De Forest adds the external electromotive force in the flux circuit, whereupon, as he states, the audion is born.

In his paper Dr. De Forest expresses the opinion that the addition of the external flux battery causes the audion to act as a relay to the Hertzian remedy.

Accepting the term relay in the sense in which it is employed in telegraphy, one is somewhat reluctant to admit that this is the function of the device. Rather it would seem that the addition of the flux battery appears to augment the Hertzian energy, or to produce a condition in the bulb that in turn enables the variations in that condition (brought about by the arriving Hertzian oscillations), to produce greater mechanical effects in the telephone receiver in the flux circuit than appears to be obtainable without the addition of the flux battery.

In other words, may there not be a certain analogy between the effect produced by the variations in the flux current in the audion, due to the Hertzian oscillations, and the greater mechanical effect produced by the presence of a permanent magnet in connection with the pull of an electromagnet and its armature? In the latter case it is known that the traction effect between the armature and its magnet is proportional to the square of the number of magnetic lines of force in action. Hence, while the arriving variations of current in, for instance, the ordinary telephone receiver, are no stronger than they would be if the permanent magnet of the receiver were absent, still by reason of the operation of the law just mentioned the resulting effect upon the diaphragm of the receiver is greater with the permanent magnet than it would be without it. But the action of the permanent magnet is not that of a relay, in the ordinary sense at least.

Dr. De Forest states that the sensitiveness of the audion under proper conditions of adjustment is twice that of any other form of wireless receiver. This obviously indicates a decided advantage if at the same time the receiver is reliable and durable and does not possess disadvantages that may outweigh the high degree of sensitiveness claimed for it; on which points no information was supplied.

The electrolytic receiver or polariphone, as it is sometimes termed, is perhaps the simplest of the efficient long-distance wave detectors. The proneness of the fine wire to burn out is its chief disadvantage. However, it requires no machinery for its operation, and only one or two very small dry cells for polarization purposes. The magnetic detector which ranks next to the polariphone in sensitiveness requires for its operation a revolving magnet or revolving iron core with the necessary motor.

The audion in turn requires a heat battery of four to eight cells, depending on the nature of the filament employed, and ten to eighteen cells for the local or flux battery. Further experience may render a reduction in the number of cells possible, but at present it would seem that the necessity for the employment of this comparatively large number of cells, together with the uncertain life of the filament, must react more or less against the general use of this type of receiver.

On the other hand, the readiness with which this beautiful receiver, scientifically considered, lends itself to various methods of tuning, its irresponsiveness to atmospheric electricity and its immunity from injury by the violent impulses of the near-by transmitter, are obviously important advantages upon which Dr. De Forest is certainly to be congratulated.

The desideratum, however, in the case of systems which, like wireless telegraph systems, go into the hands of men of all degrees of expertness and intelligence, is to obtain the utmost simplicity of apparatus, and we look for improvements in this rather than in an opposite direction. Indeed, we have no doubt that the near future will find the wireless telegraph art in possession of a receiver which will combine in itself the qualities of reliability, sensitiveness and efficiency, without the aid of moving parts or external batteries of any sort.

A receiver which appears to conform to the requirements above outlined has been developed by G. W. Pickard. The principle employed in this new receiver is that of the thermo-electric couple. The electrodes employed by Mr. Pickard in this receiver are pure silicon and a metallic element of low resistance. According to the inventor, the receiver oscillations are converted into heat at the high-resistance junction of the element having high thermo-electromotive force with the low resistance or metallic element, the amount of heat developed being in accordance with the C^2R law, the energy of which heat is converted into direct electric currents that are heard as sound in a telephone receiver. The sensitiveness of this receiver is stated to approximate that of the electrolytic receiver.

Gas-Producer Electric Plants

THE increasing importance of gas power in the generation of electricity is again brought to our attention by Mr. Bibbins' article and Mr. Windsor's paper, appearing elsewhere in these pages. In spite of the disadvantages which are inherent in the gas engine for central station operation, it appears to have well established the fact of its fitness for just this work.

Perhaps the worst that has been said about the gas engine is that it lacks overload capacity,—inability to stand up under sudden increases of load such as obtain in electric railway work,—and that its range of economical load is practically limited to between 50 per cent. load and full load. To overcome the first disadvantage the suggestion has been made that a storage battery be employed as an auxiliary or that spare units with corresponding equipments for gas storage and immediate generation of gas be provided.

One noteworthy suggestion is that of H. G. Stott. He would equip a plant with a gas-engine outfit of a capacity 50 per cent. of the total plant capacity, a steam turbine equipment making up the remaining 50 per cent. The gas-engine cooling water would be used for feed-water, and the exhaust gases used in economizers or directly in boilers or superheaters to generate steam.

Concerning this feature of the gas engine, neither Mr. Bibbins nor Mr. Windsor alludes, but it may be assumed from the statement of the latter that he is absolutely convinced of the economy and reliability of a gas-engine power station, that no trouble on the score of small overload capacity is had in the Boston plant. It may be said, in passing, moreover, that overload capacity is largely a matter of builders' rating. No engine, whether gas or steam, will operate satisfactorily beyond a certain limit. It remains, then, to make the nominal rating such that, while economical operation is assured, a satisfactory overload capacity is also provided.

The fuel economy of both plants appears to be remarkably high. Mr. Windsor says that his company found the fuel consumption to be one-half that of a steam plant, or $1\frac{1}{2}$ pounds to $1\frac{3}{4}$ pounds per kilowatt-hour. In the Keene plant, which is somewhat smaller, being about 400 H. P., while the Boston plant is 700 H. P., the fuel consumption varied from $2\frac{1}{4}$ pounds per kilowatt-hour at $14\frac{1}{2}$ per cent. load factor to 1.85 pounds per kilowatt-hour at $66\frac{2}{3}$ per cent. load factor. Figures given recently by W. P. Hancock, of the Boston Edison Company, show that for a 10,000-KW. steam turbine plant with a load factor of $64\frac{1}{2}$ per cent. the fuel consumption was 2.6 pounds per kilowatt-hour.

Another disadvantage cited against the gas engine has been its large capital cost, yet in the case of the Keene plant capital cost was far outweighed by considerations of economical operation. The object sought was to obtain a means of generating electric current at small cost, and this condition the installation is fulfilling. On the score of heat losses alone the gas-producer appears to have a marked advantage. With a steam plant, the heat losses are made up of loss to stack, boiler radiation and leakage, pipe radiation, leakage and drips, loss to feed pump, to circulator, heating, engine radiation, and loss to the condenser. These, combined with engine friction and generator losses, according to H. G. Stott, make the heat units delivered at the bus-bar as electric current but about 10 per cent. of the total in the coal.

With a gas-producer plant the losses are found in the gas producer and auxiliaries, the cooling water, the exhaust gases, engine friction and generators, aggregating about 76 per cent., and leaving 24 per cent. of the heat units in the coal to be delivered at the bus-bars as electric energy.

Of course, the figures given in the foregoing show the result of years of development in both engine and producer. Ten years ago the small gas engines gave a thermal efficiency of about 16 per cent. To-day, with units of 1500 and 2000 H. P., a thermal efficiency of almost 30 per cent. is obtained, and even nearly 40 per cent. is said to have been obtained abroad.

As to the producer, the problem of successfully using anthracite and non-coking bituminous coals seems to have been solved. The use of the richer bituminous and semi-bituminous coking coals of the Eastern States appears to be still a somewhat unsolved problem. From Germany we hear, however, that gas producers are operating on city refuse, mine culm, and the like, making possible the use of material unsuited to the steam boiler.

Institutional Telephone Service

THE selection of telephone service for a public or private institution involves a number of practical considerations which ought not to be overlooked. The type of system desirable, the number of stations needed at present and anticipated for the future, the probable amount of interior communication and the forecast of intercourse with the outside world, the question of purchasing one's own equipment for interior service or of buying exchange service for the entire installation,—these points must all be taken up in relation to their cost and advisability before an intelligent decision can be reached.

Perhaps the brief discussion of the points at issue in the selection of a system for a large professional school may throw some light upon the practical side of the institutional telephone problem. In the case in point telephones were needed for both interior and exterior intercourse. The first question that came up was the use of an inter-communicating system. It was realized that such systems are in successful use in many buildings without the intervention of a central operator, but the best results are secured when there are not too many instruments. When an attempt is made to install such a system in a group of buildings, even if there are not many instruments in a building, the wiring becomes complicated and expensive, since all the wires have to be carried to each telephone. Hence good service is difficult to obtain; such systems are not capable of ready extension, as a rule, and for these reasons were not considered desirable in the school.

The alternative choice was the equipment of a central station in the executive offices, keeping an operator on duty from 8 A. M. to 6 P. M. Two systems of this kind were considered: a private line system owned by the institution and one rented from the local telephone company. With either system each instrument would connect with the switchboard in the executive offices, where the operator would join local calls, but the private system could not be connected with the public exchange service on account of the well-known Bell practice of avoiding connection with so-called non-standard apparatus. No independent exchange service was available in this instance, and the rented Bell service was selected because of its reliability, freedom of responsibility for repairs on the part of the institution and the value of having any instrument on exchange service.

Forty telephones were required, one telephone being installed on the floor of each wing of each building in the establishment. It was estimated that the cost of installing the private system would be about $25 per station, including wiring, switchboard and instruments. This was about 50 per cent. above the estimated cost of installing the local telephone company's service. It was estimated that the yearly cost of operating thirty-five private stations and five stations on exchange service would be about $30 per telephone, against $21 per telephone with the regular rented service.

The private-branch exchange operative services were figured at $400 per year in this allowance. Allowing 10 per cent. interest and depreciation on the investment in the private system, and 10 per cent. more for maintenance, the fixed charges and repairs came to about $2.50 per telephone in the private system, making a total of $32.50 per station against the $21 charged by the local company. It was, therefore, deemed best in this particular instance to select the Bell service.

In view of the fact that some of the members of the teaching staff are frequently called by outside parties, it was found undesirable to locate telephones in the hallways for this purpose, as there would not be regular attendance at such stations to answer calls. The scheme of having one telephone in each building located in an office from which call boys can be sent out was considered, but, aside from the obvious inconvenience of such a system, the cost was found to be greater, except where office and call boys are needed for some other purpose.

Each call boy would cost at least $150 per year, against $6.50 or $12 per telephone station, according as such a telephone was restricted to local calls in the institution or was permitted exchange calls. The requirements of calling up individual professors were best met by installing separate instruments in each professor's private study.

To provide for the calling up of the instructors after the closing hour of the school, special trunk lines to the private branch exchange switchboard were provided at a cost of $36 per year each. This trunk line was given a number under the professor's name for $6 per year additional. When the operator in the executive offices left the switchboard for the day she plugged in the trunk line with the professor's instrument, so that outside calls could be freely handled, as well as originating calls in the professor's study, by the regular exchange operator of the telephone company, although the inter-communication system in the school was unavailable on account of the absence of the operator. This arrangement had the advantage of being available for any instrument at any time, and of not being necessary when the system was first installed.

The wiring in this institution was installed so that additional instruments could be connected in with a minimum of expense, bearing in mind the common experience that more stations are generally required than are at first thought necessary. To simplify the wiring as much as possible, cables were run from the private-branch switchboard in the executive offices to cable boxes in the centre of each building wing; from these cable boxes conduits were run up through each building touching at a small junction box on each floor. No wiring was done beyond the basement cable boxes until each telephone was installed, when wires were run for each instrument behind a special moulding, located for that purpose in each corridor, to the junction box on that floor and thence to the cable box in the basement.

Finally, several automatic instruments of the coin-depository type were installed at various points to relieve the school of all care and leave the operator free for her regular work. The combination of pay stations, trunks and private telephones in the branch exchange gave a well-rounded institutional system.

Gas-Power Electric Plants

By PAUL WINDSOR, Chief Engineer of Motive Power of the Boston Elevated Railway Co.

A Paper Read at the Convention of the American Street and Interurban Railway Engineering Association

THIS paper deals with the experience of the Boston Elevated Railway Company with its two gas-engine plants. These have now been in operation, one about four months, and the other for a few weeks.

A little over a year ago the subject came up of supplying power to two sections of the railway that were rather hard to reach from the present power stations, and as we had for some time been looking into the question of gas engines, it was decided that this was a good opportunity to make a trial of them. Both plants are small, one of 700 KW., and the other of 975 KW. The engine load factor in both stations can be made extremely good, as they feed into the trolley lines in multiple with the steam stations of the road.

The buildings are of brick and concrete throughout, with reinforced concrete floors and flat roofs, with a great deal of light and ventilation.

The equipments of these two plants are radically different. The Sommerville plant has down-draught suction producers and 4-cycle, single-acting engines, and the Medford plant has up-draught pressure producers and 2-cycle, double-acting engines.

Unfortunately the Medford station has been operated so little—through no fault of the equipment contractors—that no figures are available, and the writer must, therefore, confine most of his remarks to the Sommerville station.

The Medford station has R. D. Wood gas producers, with blowers, tar extractors, scrubbers, etc.; Koerting 2-cycle, double-acting gas engines, and Crocker-Wheeler generators.

The gas plant is similar to, although larger than, the United States Government Testing Plant at St. Louis, which has been in continuous operation now for two years or more, making gas successfully from all kinds of coal.

The engine plant is similar to, although smaller than, the Lackawanna Steel Company's plant at Buffalo, where a large number of these engines run successfully on blast-furnace gas. As before stated, the Medford plant has been run very little. This has not been the fault of the plant, but has been owing to the company's wishing to thoroughly work out the exhaust question before putting the plant into regular operation. The station is in a residential district, and the noise of the exhaust of the one engine started was such as to seriously annoy the neighbours. We have, therefore, been experimenting for nearly two months, during which time only one engine has been run, and that very little, so that no economy tests have been possible.

The Sommerville station has a Loomis-Pettibone gas plant, with the necessary exhauster, scrubbers, holders, etc.; American-Crossley engines, and Crocker-Wheeler generators.

The Sommerville station has been in commercial operation since May 4, 1906, and up to August 31 it has used 1.45 pounds coal per kilowatt-hour.

During May—from May 4 to May 29, inclusive—but one engine was in use. Since then two engines have been running. The station is run week days from 7 A. M. to 11 P. M., and on Sundays in the afternoon only. The engine load factor has been about 74 per cent.

On June 10 a thirty days' test run was begun. During these thirty days the station was run 16 hours per day, from 7 A. M. to 11 P. M., with an engine load factor of a little over 70 per cent. The average Pocahontas coal per kilowatt-hour delivered from the station was 1.31 pounds. This included all the fuel used, whether for running the engines, building fires after cleaning, or in the auxiliary boiler.

From May 4 to Sept. 3, inclusive—the four months in which the station has been in regular commercial operation—the fuel per kilowatt-hour output has been 1.45 pounds. These figures are as good as the most enthusiastic have ever hoped for. The plant has proved its reliability, and the shut-downs have been very few. There have been no shut-downs of any kind in the gas house. This portion of the plant has run regularly and without any trouble and has made a uniform grade of good gas.

In the engine room there have been interruptions, but these have almost all been of the kind to which any new power plant is subject. The longest delays, in fact the only real shut-downs, were due to improper water connection with the piston. This matter, however, has been remedied. We have had one case of hot crank-pin, probably due to too quick starting. These engines can be set running so quickly—well inside of 60 seconds, and often to 30 seconds—that the temptation has been to see how quickly it could be done, resulting, as before stated, in one case of hot crank-pin, the oil not having been given time to reach it after 6 hours' shut-down.

As a result of experience with these plants, the writer is absolutely convinced of the economy and reliability of a gas-engine power station. The fuel consumption will be about one-half as compared with a steam plant, running from less than $1\frac{1}{2}$ pounds to $1\frac{3}{4}$ pounds, according to the load factor and almost regardless of the size of the plant, as against 3 to 4 pounds in similar steam plants.

The cost of the gas plant, including producers, is undoubtedly considerably higher than the cost of a similar sized steam plant, and whether the fuel saved will justify the increased capital depends on the price of coal, but it seems that with coal at $3 and upwards there will be a material net saving by the use of gas.

Another advantage of a gas plant is the high efficiency of a small plant, the efficiency being practically the same for engines as small as a couple or hundred horse-power as for those of larger size, which of course is not true of a steam plant.

The question is of course asked: "What are the disadvantages of a gas-power station as compared with a steam plant?" The writer is glad to say that they are few. The gas-producing portion of such a station is simpler, easier to operate, and holds its efficiency better than a steam plant. The losses from banking fires are extremely small, and the plant can be gotten into service much more quickly than can a steam plant.

It is our practice to shut down at 11 at night and start at 7 in the morning. Fifteen or twenty minutes are required to get the gas plant into full operation, while of course with a boiler plant it takes from 1 to 1½ hours to get the fires into first-class shape. The ashes have to be periodically removed from the producer. In our plant this has to be done while the producers are out of commission and takes about 3 hours twice a week, although the plant can be run a couple of days longer without cleaning, if necessary.

With some forms of producers the cleaning can be done while the plant is in operation, but the writer has had no experience on this point yet, as the company's second plant, which has this form of producer, has not been in continuous operation. The wet and dry scrubbers have to be cleaned every few weeks, but this work is certainly no more difficult than the work required around a boiler, cleaning soot from the tubes and from the soot-chambers.

An ordinary gas man, such a man as would be considered a first-class fireman, can run at least as many horse-power of gas producers as he can of boilers. He can make a very uniform grade of gas and will get regularly very much nearer the possible efficiency from the gas producers than from the boilers. We have, however, found the "Ardos" CO_2* recorder of great assistance. Without it we found that the gas man would vary his CO_2 from 5 to 7 per cent., while with it he would hold it below 5 per cent. It is, of course, much more satisfactory for a man to know actually what he is doing from minute to minute than to work entirely on his judgment.

The ordinary steam engineer is, of course, afraid of a gas engine, just as a stationary engineer is afraid of a locomotive, but a few months' practice should make of a good steam-engine runner an equally good gas-engine runner. The handling of the water jackets is, of course, extremely simple. The problem comes in the ignition, but with a well-designed gas engine, equipped with a duplicate system of igniters, there would be little, if any, trouble.

A gas engine will hold its efficiency much better than a steam engine. With a steam engine, poorly set or leaky valves will interfere seriously with its efficiency. With a gas engine the effect of improper ignition or valve setting, or even leaky valves, is generally either to cause a knock, therefore at once announcing itself, or to reduce the output of the engine. None of these things materially affects the efficiency without showing also in other ways.

The water required is considerably less for a gas plant than for a condensing steam plant and considerably more than for a non-condensing steam plant. A non-condensing steam plant will use for all purposes from 40 to 50 pounds of water per kilowatt-hour. A condensing steam plant will use from 20 to 30 pounds for steam, and from 600 to 900 pounds in the condenser per kilowatt-hour. A gas plant will use about 200 pounds per kilowatt-hour.

The only two serious troubles that we have had have been premature explosion and back-firing in the engines and noisy exhaust. The exhausts we now have pretty well under control and certainly they can be made entirely unobjectionable, if not noiseless. Premature ignition and back-firing have both given a good deal of trouble, and on both types of engines have at times been bad, so bad as to materially reduce the engine power for the moment. This trouble is now much less than it was, and even if not further eliminated will not interfere with the regular and commercial operation of the plants.

There are many forms of producers that can be used successfully with hard coal, using sizes at least as small as pea and as small as No. 1 buckwheat if it is of good quality. Soft coal cannot be used in most of the producers without the addition of tar extractors. Much soft coal has been used at the Government Testing Station at St. Louis, the tar extractors doing their work very successfully.

Soft coal can be used in down-draught producers, such as are in the Sommerville plant, without any tar getting into the gas, the tar being "cracked" on passing through the hot fires, breaking up into gas and some lamp-black, this lamp-black dirtying the scrubber water to such an extent as to make it objectionable if turned into a clear stream. This lamp-black can, however, easily be separated from the water by allowing the water to become quiescent in a comparatively small tank, the lamp-black rising to the surface.

For many years and up to very recently, gas engines have been made by comparatively small companies and in small sizes, most of them following closely the early gas engines in being single-acting and having trunk pistons. This form is not adapted to large sizes, being expensive, if not impossible, to build, and requiring a great deal of oil. Most of the engines have been and are being built on the 4-cycle principle, there being, so far as the writer knows, but one large manufacturer of 2-cycle engines.

In the last two years the large steam-engine manufacturers, such as the Allis-Chalmers Company, of Milwaukee, Wis.; the Snow Steam Pump Company, of Buffalo, and the Westinghouse Machine Company, of Pittsburg, Pa., have been making large gas engines, and there have been a considerable number of engines of from 2000 H. P. and upward run during the past year, so that to-day there is no trouble in purchasing engines of standard design in the large sizes.

All three of these companies have adopted the successful designs of steam engines to the gas engines, using disc-cranks and double-acting cylinders, generally two cylinders in tandem, giving two impulses to each revolution of the crank, as with the single-cylinder steam engine. In the larger sizes they use the two-crank arrangement with the generator or fly-wheel between, each crank having two double-acting cylinders. The valves are always poppet valves, both intake and exhaust driven from a lay shaft parallel with the cylinder.

As this problem has been taken up independently by these three large and successful steam-engine builders, and all have arrived at practically the same solution, it is safe to say that the gas engine of the immediate future will be of this type.

The equipment of the Medford power station consists of the following:—

GAS HOUSE

Five up-draught water-sealed gas producers, 9 feet in diameter, built by R. D. Wood & Co., of Philadelphia.

One auxiliary steam boiler, coal fired.

One 40-H. P. engine, for blowers and tar extractors.

Five economizers for preheating the air for producers.

Five wet scrubbers.

Two tar extractors.

Two sawdust purifiers.

One 15,000-cubic foot gas holder.

ENGINE ROOM

Engines.—Three single-cylinder Koerting, 2-cycle, double-acting gas engines, built by the De La Vergne Machine Company, of New York. Cylinder, 25½ inches diameter by 45-inch stroke. Speed, 100 revolutions per minute. Rated capacity, 500 brake H. P. each.

* This was described in the April, 1906, issue of the Electrical Age.

Ignition.—Duplicate "make-and-break" electrical igniters. Igniter current from vibrating magnetos mounted on engine.

Generators.—Three direct-connected railway generators, built by the Crocker-Wheeler Company, of Ampere, N. J. Rated capacity, 325 KW. Normal voltage, 500 volts. Normal amperes, 591.

Switchboard.—Arranged for three generator and six feeder panels and one station panel, circuit breakers, recording wattmeters and voltmeter, etc.

Overhead Crane.—The overhead crane is hand-operated and supplied with an 8-ton and 1-ton hand hoist.

Water Supply.—The water is supplied from three 8-inch artesian wells of an average depth of about 550 feet.

Rating.—The normal rating of the station is 975 KW. Maximum capacity, 1300 KW.

The equipment of the Sommerville power station consists of the following:—

GAS HOUSE

Two Loomis-Pettibone soft-coal down-draught producers, 9 feet in diameter, built by the Power & Mining Machinery Company, of Cudahy, Wis.

One regenerator boiler.

One coal-fired auxiliary boiler.

One vertical wet scrubber.

One Root exhauster, steam-driven, with electric motor as auxiliary.

One dry scrubber.

One 15,000-cubic foot gas holder for producer gas.

One 5000-cubic foot gas holder for water gas.

ENGINE ROOM

Engines.—Two two-cylinder American-Crossley, 4-cycle, gas engines, built by the Power & Mining Machinery Company. Cylinders, 32 inches diameter by 36-inch stroke. Speed, 140 revolutions per minute. Rated capacity, 600 brake H. P. each.

Generators.—Two Crocker-Wheeler direct-connected railway generators. Rated capacity, 350 KW. each. Normal voltage, 550. Normal amperes, 636.

Ignition.—Duplicate "make-and-break" electric igniters on each cylinder. Igniter current supplied by two motor generators and a storage battery.

Switchboard.—Arranged for two generators, five-feeder panels and one station panel, with circuit breakers, recording watt-meters and voltmeter, etc.

Overhead Crane.—Hand-operated, with an 8-ton and a 1-ton hand hoist.

Water Supply.—From Alewife Brook, by two-stage, centrigugal, motor-driven pumps. Filtered by a pressure sand-filter.

Rating.—Normal rating, 700 KW. Maximum capacity, 933 KW., or 33 per cent. overload.

FOURTH DAY ECONOMY TEST—July 12, 1906.

Duration of run (hours)			16
Kilowatt-hours output			9,480
Pounds coal in producers		13,000	
Pounds coal in boiler		....	
Pounds of coal, total			13,000
Pounds coal per kilowatt hour			1.37
Load factor. Electric			84.5%
Load factor. B. H. P.			72.1%
Cubic feet mixed gas			1,397,000
Cubic feet water gas			50,500
Cubic feet producer gas			1,346,500
Per cent. water gas			3.61%
Cubic feet mixed gas per hour			87,400
Cubic feet mixed gas per kilowatt-hour			147.3
Pounds coal			107.5
Mixed gas B. T. Us	High		126.5
Mixed gas B. T. Us	Low		122.5
Water gas B. T. Us	High		288.7
Water gas B. T. Us	Low		269.5
Producers gas B. T. Us	High		120.8
Producers gas B. T. Us	Low		117.0
Cubic feet water—7 A.M.-11 P.M.			32,045
Water cooled valves		1,038	
Economizer		277	
Scrubber		7,445	
Engines and waste		23,285	
			32,045

THIRD DAY ECONOMY TEST—July 11, 1906.

COAL ANALYSIS.

	As received	Dry Coal	Combustible
Moisture	2.30	....	....
Volatile matter	18.48	18.90	20.25
Fixed carbon	72.79	74.52	79.75
Ash	6.43	6.58	....
B. T. Us per pound	14,030	14,360	15,380

THIRD AND FOURTH DAY ECONOMY TEST.

July 11 and 12, 1906.

MIXED GAS ANALYSES.

Date	6/11/06	6/11/06	6/12/06
Time, P.M.	5:05	8:25	5:12
CO_2	3.5	3.0	3.6
O	.2	.2	.2
CO	26.9	27.4	27.2
CH_4	1.2	1.0	1.1
H	9.9	9.1	8.5
N	58.3	59.3	59.4
B. T. Us at 60° F	132.1	133.8	127.5

EXHAUST GAS ANALYSIS.—July 31, 1906.

Sample taken from elbow at muffler of engine.

No. 1.—A end.

CO_2	11.7%	volume.
O	13.0%	volume.
CO	trace	
N	75.3%	volume.
	100.0%	

This sample shows that an excess of air of 65 per cent. was being used at the time the sample was taken.

Underground Cables

By H. G. STOTT, Superintendent of Motive Power, Interborough Rapid Transit Co., New York

A Paper Read at the Convention of the American Street and Interurban Railway Engineering Association

UNDERGROUND cables may be grouped into three classes, as follows:—

First. High-tension multiple or single conductor cables of relatively small current carrying capacity, but capable of operating under working pressures from 2500 to 25,000 volts mean effective pressure.

Second. Low-tension single-conductor cables of large current carrying capacity, but operating only under pressures of 650 volts or less.

Third. Negative return cables of large current carrying capacity, but operating only under a pressure corresponding to the drop in the return feeders.

The first class, comprising what is popularly known as high-tension cables, has developed by a process of evolution from the time when nothing but rubber was used for insulation to the present time where rubber, varnished cambric, saturated tapes and paper insulation have been brought to such a state of perfection as to leave little to be desired.

Higher voltages than 25,000 have not yet been attempted in underground cables, but there seems to be no reason why a voltage of 44,000 should not be used with exactly the same degree of safety as 25,000, provided a star connection is used in the transformers and the neutral point is grounded, for then the maximum strain is limited to 25,000 volts to ground.

It would thus seem that our cable manufacturers have almost kept up with the development in overhead construction, as at this time 60,000 volts are the maximum pressure in use in a few cases only, and the great majority of important transmission schemes are under 50,000 volts.

For economic reasons, principally, rubber insulation is only used where local conditions seem to demand an insulation which is impervious to moisture, so that in case the lead sheath should be punctured, the cable will not necessarily fail. As an instance, where cables have to be installed in ducts which are under water part of the time, or for submarine cables, the extra investment for rubber insulation would seem to be justified, as in the event of a leak in a submarine cable lead sheath it usually becomes a total loss if insulated with paper or other non-moisture proof material, whereas good rubber will last indefinitely under water.

For potentials above 22,000 volts it seems likely that some form of varnished cambric or impregnated cloth will take the place of paper, owing to its higher puncture resistance for a given thickness, but experience with working pressures above 22,000 is so limited that we must wait for some time before any definite conclusions can be reached.

As the result of some fifteen years of experience with underground cables, the following table, giving thickness of insulation and lead sheath for various sizes of conductors and working pressures, is submitted as representing conservative practice:—

TABLE No. 1.
PAPER INSULATION.
Standard Working Pressure of 3,000 V.

SIZE OF CONDUCTORS.	Thickness of Insulation.	Thickness of Lead.	
		Single Cond.	Three Cond.
No. 6 to No. 2 B. & S.....	5/32"	5/64"	3/32"
No. 1 to No. 00..........	5/32"	3/32"	7/64"
No. 000 to 300,000 c.m....	6/32"	7/64"	9/64"
400,000 to 750,000 c.m....	6/32"	7/64"	....
800,000 to 1,000,000 c.m...	7/32"	4/32"	....
1,250,000 to 2,000,000 c.m.	8/32"	9/64"	....

For each 1000 volts increase of pressure above 3000 add 1-32 inch insulation to the wall until 11,000 volts are reached, and after that add 1-64 inch for each 1000 volts. For example, the insulation required on a No. 0 B. & S. 25,000-volt cable would be 20-32 inch or 5-8 inch.

If 35 per cent. para rubber compound or varnished cambric is used for insulation, the above empirical rule may be changed to read: For each 1000 volts increase above 3000 add 1-64 inch insulation to the thickness of wall until 25,000 volts are reached.

For the insulation of low-potential cables in Class II., 4-32 inch paper should be used on all sizes up to 1,000,000 c. m., and from 1,250,000 to 2,000,000 c. m., 5-32 inch should be used.

From a purely electrical point of view, one-half of this insulation would be ample to withstand 650 volts of working pressure, but the mechanical effects of reeling and unreeling the cables and pulling it into ducts and bending around the manholes are to practically destroy the insulating qualities of the layer of paper next the lead, so that we really start in with a cable having approximately 1-32 inch of its insulation destroyed before it is put into commission. This mechanical destruction of insulation is especially marked in cold weather, as the oils used with the paper tend to congeal when subjected to a temperature below 32 degrees F.

The cable manufacturers have met this difficulty by using more fluid oil, with the result that the insulation resistance of the cable may not be more than fifty megohms at 60 degrees F., but by the use of this very soft insulation they have produced a cable giving a very low insulation, but a high puncture, test, and at the same time have met, to a great extent, the difficulty of handling paper cable in cold weather. It is always advisable, however, if a cable is to be used in a temperature below 32 degrees F., to keep it in a warm place, such as a boiler room, for at least twelve hours before drawing it in. The cable may then be used in the coldest weather, as it gives up its heat very slowly.

The cables in Class III. have, up to within the last three years, received very little attention, as, in almost every case, bare copper cables were installed. But a closer study of the electrolysis problem indicates that in many instances the use of insulated, negative cables would eliminate a great deal of the trouble and damage to cable sheaths, etc.

When electricity leaves a conductor in wet or moist ground, the water in its path is decomposed into its constituent gases. And oxygen has an affinity for almost all metals, forming an oxide of iron or oxide of lead or copper, as the case may be.

In the ordinary location of direct-current power plants in our smaller cities, only one generating station is used, and sufficient positive copper is installed to give the necessary potential on the trolley, the negative or return circuits being taken care of by the track rails up to the nearest point to the power plant or sub-station, and from this point bare negative feeders are used to conduct the current back to the grounded negative bus in the station.

The maximum amount of copper installed in this negative rarely equals that used for the positive, so that in all probability there will be at least five volts drop from the nearest track rail to the negative bus, and if longer bare negative feeders were used running to the various points of heavy traffic, the drop on them would be at least 4 per cent., as the financial burden caused by interest on capital invested becomes too great if a smaller drop than this is used. We thus have bare negative feeders with a potential of from five to twenty-five volts on them, running parallel to our positive and high-tension feeders, as well as our neighbours' cables, gas mains, water mains, etc., and a few bad rail bonds may increase this drop several per cent.

The negative feeder may, therefore, be looked upon as an infinite number of small battery cells coupled in series, with their negative poles coupled to the negative bus in the power house or sub-station, and their positive coupled to the track rail, with some good and some bad connections, all along the line to the various lead sheaths of the cables running near them, as well as to gas mains, etc. If the connections between one of these imaginary cells and a lead sheath be sufficiently good, then this battery's potential of perhaps ten volts will be on the cable sheath and will cause a current to flow from it at some other point along the line where the negative return is at a lower potential. At the point where the current leaves the lead sheath electrolysis will occur, and in time the feeder will break down from the moisture admitted through the perforated lead sheath.

The above conditions obtain to a greater or less extent in all systems having bare negative returns and grounded negative bus-bars, no matter how many sub-stations may be in use.

An obvious remedy would seem, at first sight, to be the bonding of the lead sheaths of all feeders to the bare negative cables at frequent intervals, but this introduces another trouble which may be as serious as electrolysis. A short-circuit in a positive feeder to ground will cause an enormous current to flow through the lead sheaths, and in all probability burn off the bonds and destroy the lead sheaths in a number of cables. Instances of this have occurred to the author's knowledge, in which the lead sheaths have been completely burned off for 400 feet on cables that were entirely innocent of the origin of the trouble.

Another source of trouble, due to the use of the grounded negative bus and bare feeders, is in the other feeder's lead sheaths carrying the negative current back to the power house or sub-station by an entirely different route from that taken by the bare negative feeders, with the result that this return current leaves these lead sheaths, either in the power house through a ground put on them, or through some accidental ground, such as a cable hanger in a manhole. Every time a short-circuit comes on the system a rush of current will flow through these lead sheaths, and, perhaps, puncture small holes in the lead.

The most satisfactory solution of these problems of avoiding electrolysis and saving the lead sheaths from destruction seems to be in the use of an insulated negative bus in the power house and sub-station, and insulated negative feeders right up to the track rails. For this purpose, the negative feeders should preferably be insulated with some material which does not require the use of a lead sheath. Several types of insulation are now on the market, which promise to be very satisfactory for this purpose, as the potential carried by the negative feeders is quite low.

The ideal solution of the problem would be found in the use of the feeders without lead sheaths, and some very satisfactory tests are now being made on experimental lengths of 650-volt cable of this type; but it does not seem probable that any cable can be constructed at present which will safely stand being drawn into wet ducts and manholes and used continuously on pressures above 2000 volts without the protection of a lead sheath to keep out the moisture.

By using insulative negative feeders and avoiding all grounds in the power house or sub-station, it is evident that there will be little or no tendency for the return current to leave the track rails, if properly bonded, and absolutely no tendency for stray currents to come back to the power house or sub-station by way of lead sheaths, gas mains, etc., thereby relieving us of probably 75 per cent. of our present electrolysis troubles.

Coming back to Class II. cables, the safest plan seems to be to insulate the lead sheaths of all feeders by supporting them on racks having some form of insulation between the lead sheath and the hanger.

All cables should also be wrapped with two layers of ½-inch asbestos in every manhole where more than one cable is on each side, in order to afford protection from an arc caused by any one of them burning out. In perfectly dry places this asbestos wrapping can be secured very neatly by applying silicate of soda to it, the soda in itself being a good protection against fire; in the average damp manhole this soda will soon loosen and the asbestos wrapping will fall off, so that, in this case, a galvanized steel tape about ⅝ inch by 1-32 inch should be used to hold the asbestos in place.

In order to get early warning of the breaking down of any positive feeder, and to give time to have it cut out before doing any further damage to itself or neighbours, a small insulated wire, say No. 14, B. & S., should be connected to the lead sheath and brought up to a panel where the switchboard operator can see it. On this panel may be mounted one or two lamps for each positive feeder, and these lamps connected to ground through a resistance large enough to limit the current to the amount necessary to light the lamps when the pilot wire attached to the lead sheath to any feeder becomes alive through the grounding of that feeder on its insulated lead sheath. Ammeters or relays operating a gong may also be used with advantage for this purpose at a very small cost per feeder.

In reference to Class I., or high-tension, three-phase cables, their lead sheath should be insulated and wrapped with asbestos in the same manner as described for Class II., with the additional precaution that their lead sheaths should all be bonded together and grounded in the generating plant. The neutral, or star point, of the generators or transformers, should be grounded through a resistance of such dimensions as to limit the current flowing through it when a ground occurs on a high-tension feeder, to the amount necessary to trip the overload relay. For example, on a large installation using 11,000 volts for distribution to its sub-stations, the neutral connection is one having a resistance of six ohms and a carrying capacity of 1000 amperes for one minute. As the Y potential to ground is 6300 volts, this limits the current to a maximum of 1000 amperes when a feeder grounds.

This system was adopted after some rather disastrous experiences with short-circuits on high-tension feeders, and has been in successful operation for over a year.

When a high-tension cable breaks down, it almost invariably goes to ground from one phase only, and then, after the charging current of the whole system has been flowing to ground through this fault for perhaps ten or twenty minutes, the insulation of the other phases is burned off, so that a short-circuit on two or three phases occurs. The result is that either the whole system is shut down, due to the sudden fall of potential, to perhaps one-fourth of its normal value, or at least one or two sub-stations are shut down from the same cause. With the neutral grounded through a suitable resistance, the oil switches, on the grounded feeder only, trip out quietly without any disturbance whatever to the rest of the system.

If the three-phase, high-tension cables are not grounded in the generating plant, the burning out of a cable will puncture the lead sheath at a number of points, possibly a thousand feet away, as it is obvious that the current must leave the lead sheath somewhere, and the easiest path is usually found at the cable hangers in the manholes. This will be true no matter whether the neutral is grounded or not.

As a further precaution, it is advisable to bond the lead sheaths of the alternating-current feeders quite frequently in the manholes by wiping on a lead strap, say ⅛ inch by 2 inches, to the lead sheaths. Bonding by wrapping the lead sheaths with a few turns of copper wire is worse than useless, as the copper wire, if put on tight enough to make a good connection, may cut through the lead, and if not tight enough to do this it will probably make such a poor contact as to arc when current passes.

In conclusion, the author wishes to state that, in his opinion, at least 75 per cent. of cable trouble is caused by defects in the lead sheath and not by defects in the insulation.

Examine the ordinary vitrified duct, and you will find that the inside, in all probability, contains several small, hard, sharp points projecting from 1-16 inch to ⅛ inch. What happens to the lead sheath of a cable when it passes over these projections? A groove is cut in it in exactly the same way as by a tool in a planer. The result is that a little extra pressure, caused by a kink in the cable, will cut through the lead and admit the moisture, which, sooner or later, will destroy the insulation.

Outside of trouble in joints caused by carelessness on the part of the jointer, practically all cable trouble can be eliminated by the more careful choice and installation of conduits, by a very careful inspection at the time they are laid, and by the use of cutters and cleaners after they are laid.

Lastly, do not try to get a low price on a cable by reducing the thickness of the lead sheath, as the integrity of the lead sheath is fully as important as the quality of the insulation, and the life of the latter is wholly determined by the degree of perfection obtained in excluding moisture from it.

The Audion: A New Wireless Telegraph Receiver

By LEE De FOREST

A Paper Read at the October Meeting of the American Institute af Electrical Engineers

THE story of the development of a device of a distinctively new order, from its first inception to its practical reality, adds a human interest to its description which is, perhaps, too often lacking among scientific records. In 1900, when the writer was beginning experiments on the electrolytic responder, it was his good fortune to have to work upon it at night in his own room, at a table beneath a solitary gas-burner with Welsbach mantle. The source of Hertzian waves was the discharge of a small induction coil placed in an opposite corner and set into operation by a key closed by pulling a string.

One night the author noticed, to his surprise, a decided diminution in the light from the incandescent mantle whenever the coil was sparking. The constant recurrence of this effect induced him to investigate. By proper adjustment of the inflow of gas and air to the burner, an almost complete extinction of its light was obtained during the sparking of the coil. Another adjustment even allowed an increase of the light above normal.

For several days the writer was elated over the tremendously sensitive and altogether novel type of Hertzian-wave responder thus accidentally discovered. But alas for the over-sanguine spirits of the young investigator! When the induction coil was thrust into a closet and the wooden door closed, thus shutting off the sound of its vibrator and spark, the gas light ceased to fluctuate.

The writer found he had merely discovered an extremely responsive form of the sensitive gas flame, and that a bunch of jingling keys, or a smart clapping of the hands were almost as efficient generators of these Hertzian waves as was the induction coil. To hopes unrealized this was indeed the "Light that Failed.

But the few days of illusion had set the writer thinking. Here in the flame around this incandescent mantle was matter in a most mobile, tenuous state, extremely sensitive to sound and heat vibrations, infinitely more delicate than any arrangement of solid or liquid particles. Why should it not then in some phase or fashion respond to the Hertzian vibrations also?

Unable to dislodge this conviction from his mind, the writer began later to search for the genuine response to electric vibrations in the gas flame. The conductivity of the incandescent mantle was found surprisingly small, however, for any voltages which would be practical in a wireless receiver.

By soaking the mantle in a potassium or sodium solution and drying, it was finally possible to pass a small current from a dozen dry cells through the flame surrounding it, using two platinum electrodes with a telephone receiver in circuit, and get a faint response to the genuine Hertzian wave. The discovery that the effect predicted was actually present was intensely gratifying.

Experiments followed with the Bunsen burner and other forms of flame. In the coal-gas flame the exterior luminous portion is positively electrified, the interior negatively. To render these flames sufficiently conducting, salts of the alkali metals were introduced. Of these the cæsium, potassium, and sodium salts are the most conducting, and in the order named. These salts were either injected into the flames as solution, or preferably put in a little platinum cup held in the luminous part of the flame and made the cathode of the telephone circuit.

A platinum wire or disk held about two mm. above this cup acted as anode. The antenna and earth connection, or the two terminals of the oscillating receiving circuit,* were connected to these platinum electrodes. An electromotive force of 6 to 18 volts, supplied by a battery of dry cells, was sufficient to give a current of several milliamperes through the coloured flame.

This early form of audion, the flame receiver, was remarkably sensitive to weak high-frequency oscillations. The sound heard in the telephone was an exact reproduction of that of the transmitter spark, in pitch, variation of intensity, etc.

It was observed that the increase of current with electromotive force did not follow Ohm's law; a saturation value of the current was observed. Wilson has found that the maximum current which a salt vapour in a flame can carry is equal to the current which, if passed through an aqueous solution of that salt, would electrolyze the same quantity of the salt as was imparted during the same unit of time to the heated gas.

Beyond this saturation value the current will not rise until the electromotive forçe is great enough to enable the field itself to ionize the gas, that is, until the velocity imparted to the negative ions by the field is sufficient to enable them to separate the gas molecules with which they collide into positive and negative ions.

The conduction through flames under the conditions described is due chiefly to the negative ions generated, and these are chiefly in the vicinity of the metallic cathode. It is necessary that the alkali vapour come in contact with the glowing metal. The increase of conductivity of a flame by the addition of a salt may amount to several hundred per cent., and is due, not to the presence of the metallic atoms in the flame itself, but to the increase in ionization produced by the salt at the electrodes, notably the cathode.

The velocity of the negative ions in flames at atmospheric pressure increases rapidly with the temperature. Thus, at 2000 degrees Cent. their velocity is approximately forty times that at 1000 degrees Cent. At 1000 degrees Cent. the ratio of velocity of negative ions to positive ions is calculated as 26 to 7. At 2000 degrees Cent. this negative ion velocity in flames is about $1000 \frac{cm}{sec}$ for a po-

* For the name audion the author is indebted to his assistant, C. D. Babcock, who has been of utmost service to him in the development of this device almost from its inception.

tential gradient of one volt per centimetre.

Now suppose the average velocity of a negative corpuscle to be proportional to the electric force; this velocity, for a potential drop of 10 volts between the electrodes as the author uses them, is of the order required to traverse the distance between the incandescent body and the platinum anode during the time of one-half the wave period of the electrical oscillations ordinarily used in wireless telegraphy.

We shall return later to the bearing which this fact has upon a suggested explanation of the effect of the Hertzian oscillations upon the gas receiver.

On account of the ionization of the gas near the incandescent metal, and the greater velocity of the negative over the positive ions, it is to be expected that even if no external electromotive force be applied to the electrodes, and one of these be relatively cold, a current will pass along a wire connecting the two electrodes, the direction of which is negatively from the hotter to the cooler body in the flame. In other words, the colder body will be the anode, positively charged.

Now if the Hertzian oscillations traverse the hot gas, the momentary potentials thereby impressed upon the moving ions will conceivably interfere with their motions, or with the rates of recombination between the positive and negative ions, and thus affect the current flowing through the wire. A telephone connected between the electrodes indicates that changes of a surprising amount in the momentary potential difference, or flux, across the electrodes are effected by the high frequency oscillations, even when no external battery is applied.

When a battery of from six to twenty dry cells is connected across the two electrodes, the positive terminal to the cooler electrode, the potential current curve for the conductivity of the gas is at first approximately a straight oblique line, the current through the flame increasing with the electromotive force.

Soon, however, this proportionality of current and voltage ceases, and a stage of saturation is reached where there is no appreciable increase of current with increase of voltage. But when the potential difference is raised sufficiently to ionize the gas, a stage is reached where the current increase is far more rapid than that of potential difference. This last potential gradient depends upon the pressure of the gas; it is directly proportional to the pressure. This is given by Thomson as about 30,000 volts per cm. for atmospheric pressure; but with incandescent gases in an enclosed vessel at one mm. pressure a gradient of 40 volts per cm. is sometimes sufficient to produce this critical stage.

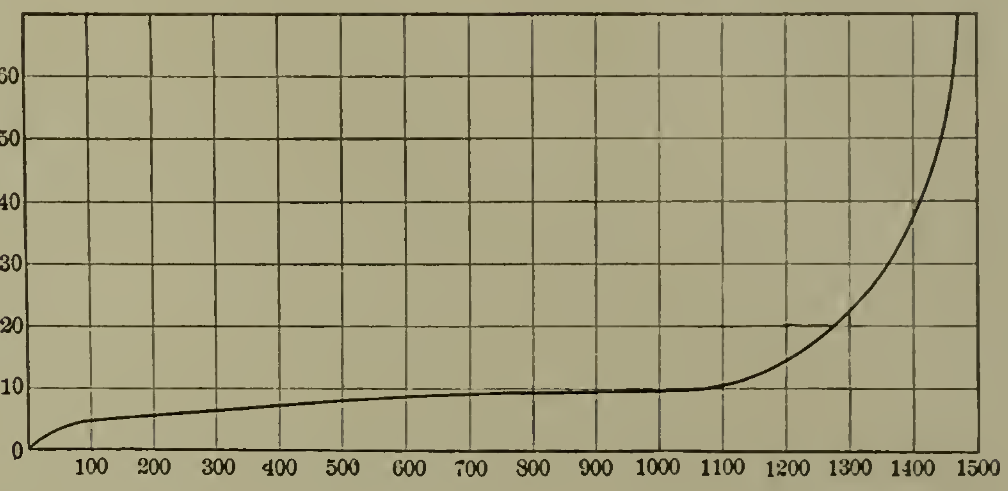


FIG. 1

In the case of the flame the distances between the electrodes figures very little in the amount of current flowing, the potential drop, or the sensitiveness to Hertzian oscillations, because most of the ionization at low voltages takes place at the electrodes.

The size and shape of the electrodes are of small moment. The writer prefers a trough anode 1 cm. long by 2 mm. wide, holding the potassium salt, as cathode, and a small platinum wire parallel thereto and held 2 to 10 mm. above it as anode.

The trough electrode should preferably be at the upper tip of the oxidizing flame at its junction with the reducing flame. When this is made negative the current is saturated with a comparatively small potential difference. The gas burner itself may be used as one electrode. The flame must be steady and kept rich in salt. The current of up-rushing flame makes a rumbling noise in the telephone, which may interfere with the detection of faint signals. This rumbling sound increases with too great applied potentials.

The temperature, especially of the electrodes, is an important factor. At red heat these give off positive corpuscles; at white heat both positive and negative appear, the latter predominating. The electrode containing the salt should always be incandescent, so that the excess of negative ions given off and streaming towards the other electrode will increase, rather than diminish, the current due to the flame itself.

The extreme sensitiveness of the flame when ionized to thermal variations is illustrated by the fact that a distinct response is heard in the telephone receiver when the mere tip of a cold pin is suddenly introduced into the flame. The sudden introduction of a cold body into the active part of the flame always reduces the response. The salt is best placed in, or on, one of the electrodes rather than held in the flame in an independent receptacle, or injected into the gas.

The applied electromotive force is a determining factor in the sensitiveness of this receiver. The response seems greatest where the potential current curve is passing from the oblique to the horizontal portion, where the saturation value is about to be reached. Under these conditions the sensitiveness of the flame audion is of the same order as that of the electrolytic receiver using a glass-jacketed electrode. The flame is not most sensitive when the flux is greatest. There is a close relation between the degree of heat and the critical impressed voltage.

Considerable difficulty was found

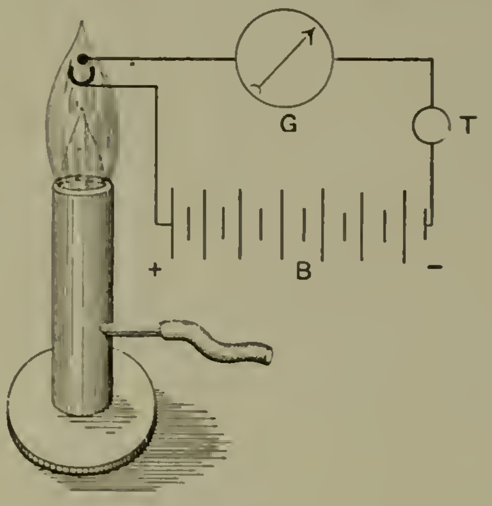


FIG. 2

in getting an absolutely steady flame, even when protected by a chimney, as the slightest air current will deflect the sensitive portion from the electrodes, altering the sensitiveness of response.

The phenomenon was next sought

in the hot conducting gases of the electric arc. If a wire be connected to the positive carbon of the arc and led through a telephone to a third electrode, platinum or carbon, which is inserted into the border of the arc, a considerable current passes

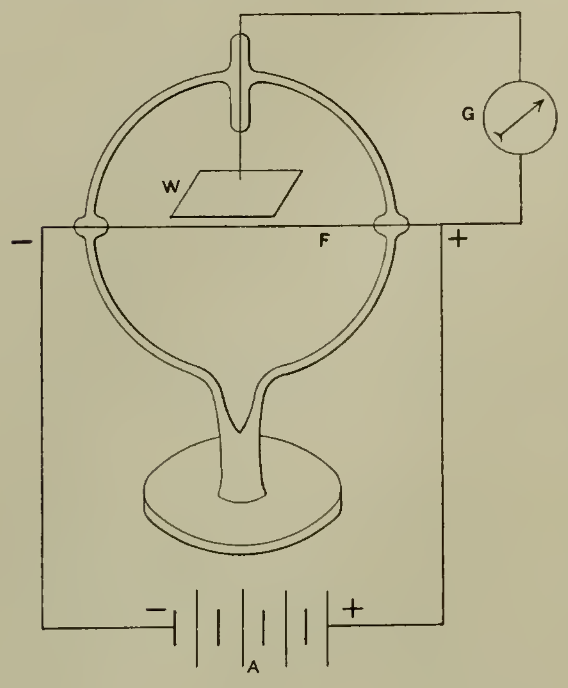


FIG. 3

through the telephone. If these two electrodes are now connected to the terminals of the receiving oscillating circuit, the conduction of the leak current across the gas to the third electrode is sensibly affected by the arriving Hertzian oscillations, if sufficiently intense. A local battery can also be inserted in series with the telephone, but the voltage drop across the arc is usually too great to require this.

Even when the arc is fed from a storage battery, and cored carbons used, the hissing and frying noises in the telephone (probably due to the oxidation of the terminal by the air) are generally too troublesome to allow a clear reading of weak signals with this form of audion.

The principles involved in its operation are much the same as for the flame audion. And although the intense ionization produced by the heat of the arc renders it extremely sensitive to slight local variations, its practical requirements make it less available as a wireless receiver.

Inasmuch as the gases ionize more readily at lower heats and are in their most mobile, delicate, and sensitive conditions in vacuum, it seemed certain, after experiments with the flame, that the attenuated and ionized gases around an incandescent filament would undergo very considerable changes when subjected to Hertzian oscillations.

Elster and Geitel,* beginning in 1882 a systematic investigation of the ionization produced by incandescent metals, frequently employed an exhausted glass vessel containing an insulated platinum plate, stretched close to which passed a fine metallic filament brought to incandescence by an electric current.

Ordinarily at atmospheric pressures and red heats a positive charge was produced upon the plate, of the order of a few volts. This potential increases until the wire is at a yellow heat. As the wire gets hotter the potential decreases, until at a bright white heat the potential of the plate is very slight. Diminishing air pressure has but slight effect upon the plate potential until very high exhaustions are reached, when this potential begins to diminish and may even change sign, and as the exhaustion proceeds may reach a very large negative value. This pressure where the plate charge changes sign depends upon the temperature of the filament, being higher at higher temperatures.

Long-continued heating and expulsion of gas from the incandescent metal play a considerable part in the electrical phenomena. Long-continued incandescence favours the negative electrification of the plate. The presence of oxygen aids in the carrying off of a negative charge, thus producing negative electrification around the wire; hence the action of oxide of metal on filaments tends to increase the discharge of negative electricity. But oxygen also hastens the disintegration of the filament.

Gases which are dissociated by heat conduct on quite a different scale from those like air, hydrogen, or nitrogen. Examples of such are the vapours of iodine, bromine, chlorine, potassium, and the like. These furnish a much larger supply of ions than the others. This dissociation occurs chiefly where the gas is in contact with the glowing electrodes. Of the metals sodium and potassium have the highest conductivity under the above conditions, for the emission of negatively electrified corpuscles from sodium atoms occurs even at low temperatures; and the writer has used carbon filaments coated with a potassium compound. The conductivity of cold mercury vapour does not seem greater than that of air.

With hydrogen, the plate becomes negatively electrified even at atmospheric pressure; and when the filament is carbon instead of platinum the electrification on the plate is always negative. This means that the gas will discharge the plate if positively electrified; that is, a positive current will pass from the plate to the filament in the gas.

The electrification produced in the neighbourhood of an incandescent wire is a complicated affair: it depends on the temperature and nature of the filament, and on the nature and pressure of the gas. It furthermore depends upon the electric and magnetic forces to which the vessel is subjected; and the writer has found that the shape and area of the plate, or plates, the condition of its surface and edges, as well as its distance from the filament, are very important factors.

If the metal plate be connected by an outside wire to the positive terminal of the hot filament, a leak-current from the plate to the filament through the gas will be set up, as Elster and Geitel first found, passing mainly to that portion of the filament near its negative terminal. If the resistance of the lamp filament and the lamp's voltage be high, a very considerable leak current may thus be set up.

In Fig. 3 a battery of from three to eighteen dry cells is connected between the positive end of the filament and the platinum plate *W*, the latter being connected to the positive pole. The saturation current increases rapidly with the heating current through the filament, which also increases the velocity of the negative ions, as does also an increase in the applied electromotive force between plate and filament.

The rate of discharge of negative electricity from glowing carbon

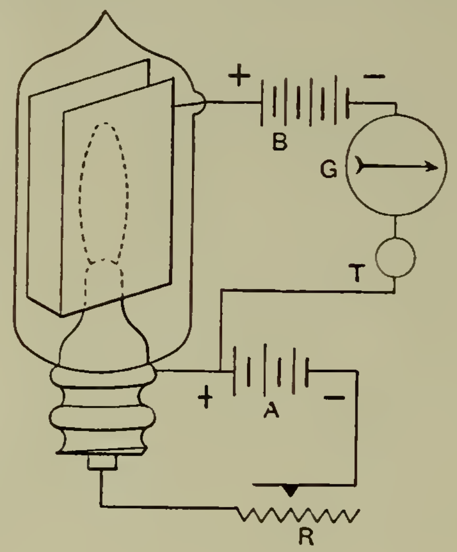


FIG. 4

greatly exceeds that from platinum, while that from tantalum and other of the newer filaments, given the same heating current, surpasses the rate of discharge from carbon.

At 2000 degrees Cent. this rate of emission from a platinum wire in high vacuo amounts to 0.1 ampere per sq. cm. of hot surface. For carbon this current can equal several

* Elster and Geitel, Wied. Ann., xvi., 1882.

amperes per sq. cm. surface. In the audion the flux current ordinarily ranges from 1 to 5 milliamperes.

The metal dust, or even vapour from the incandescent filament, may play a part in the phenomena, but not a controlling one. In many

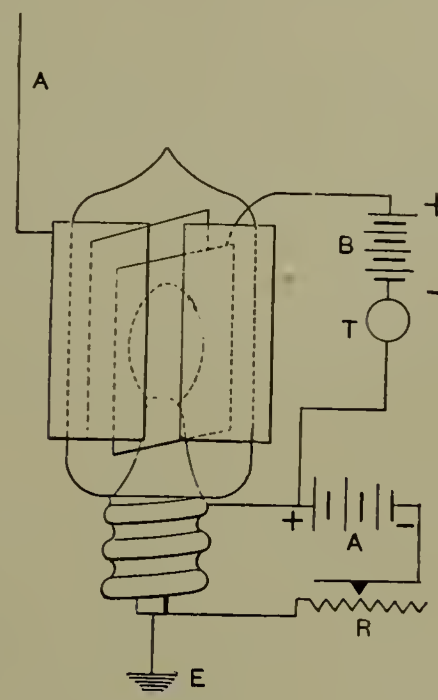


FIG. 5

ways the behaviour of the audion, notwithstanding the extremely low potentials used, is very similar to that of a cathode-ray tube; and in one or two small pea-lamps where the anode disk was close to the bend of the filament there was actually obtained, at only 22 volts, a blue-white beam of light playing between the filament cathode and the anode. Upon the approach of a powerful magnet this beam could be concentrated and deflected. A great increase in the current through the telephone marked the formation of this beam, and a violent hissing or squealing sound began when the magnet was approached.

The corpuscles at the filament are attracted by the metal of the filament, and to escape into the surrounding space they must be given sufficient kinetic energy to carry them through the surface layer where this attraction for the carriers is appreciable. Thus as the temperature of the filament increases, a larger number of the carriers can escape from the wire. But the saturation values of the flux current do not depend upon the velocity of the ions, but only upon the number of ions produced in unit time at the surface of the hot metal.

The source of ionization is confined to the gas immediately surrounding the filament. The velocity of the ion at any instant is dependent on its distance from the filament, because the temperature is not uniform between filament and plate. The ratio of the velocities of negative to positive ions varies greatly with the temperature: thus, they are given as 1000 to 62 at 2000 degrees Cent.

This fact explains why the positive conductivity of the gas in the vessel is almost entirely from the cold to the hot electrode in the gas, and not in the reverse direction, and why this uni-directional quality is more marked for higher temperatures of the cathode, the anode being kept cold.

In the form of audion illustrated in Fig. 4 two platinum wings are used parallel to the plane of the bowed filament and about 2 mm. on either side of it. These wings are soon coated with an iridescent deposit from the metal filament, especially at the portions opposite to the negative half of the filament. They become quite hot at this short distance, but not sufficiently hot to take part in the ionization of the gas.

When connected in the oscillation circuit as shown, properly attuned to the receiving electromagnetic impulse from the antenna, the audion, under proper adjustment of heating current and battery *B* potential, is extremely sensitive, giving response in the receiving telephone several times as loud as any other form of wireless receiver when subjected to the same impulses. It is, however, less sensitive to atmospheric or static disturbances, which are strongly damped or a-periodic.

The device is extremely closely tuned with the syntonizer, for its operation seems to be dependent upon the sum total of the energy received from the complete wave-train rather than upon the maximum first impulse of the train. In other words, while instantaneous as far as our senses or instruments can perceive, its action is sufficiently sluggish to be determined by the additive effort of the entire received electroradiant energy through a short time-interval.

When the filament is first lighted, an appreciable interval, about one-quarter second, elapses before the full sensitiveness is established. Before the flux reaches a steady state there is a period during which the number of ions is steadily increasing. As a result of the colliding of the initial ions with the gas molecules, the number of ions and the current rapidly increase, until an equilibrium is finally attained.

The audion, to a greater extent than any other responder, is self-tuned. By that is meant regulating the heating current, the potential between wing and filament, or the distance between these, the audion can be made to a great extent selective *per se* to certain received impulses. And the determining factor here is not merely the frequency of the electrical oscillation; the spark frequency, or factors determining the total amount of energy received during a very brief unit of time, determine to an extent the amount of its response. Thus, with 12 volts across it, it may give a loud response to a transmitter *A*, and with 10 volts "bring in" another transmitter *B* to the almost complete exclusion of *A*, although *A* and *B* are of equal power and of approximately the same wave-length, but differing considerably in spark frequency. Similar discrimination can be produced by adjustments of the heat of the filament, which also governs the amount of flux through the gas.

This flux is generally reduced when the audion is placed in a strong magnetic field, especially when the lines of force pass through the gas parallel to the plane of the wings, at right angles to the electric field. By this means also a tuning can be effected.

Again, it is not necessary to connect the anode to a terminal of the oscillating circuit. One terminal may be attached to a metal sheath or ring surrounding the glass vessel, thus forming a condenser with the filament or the conducting gas within the tube, as in Fig. 5. In this case the adjustment of the syntonizer

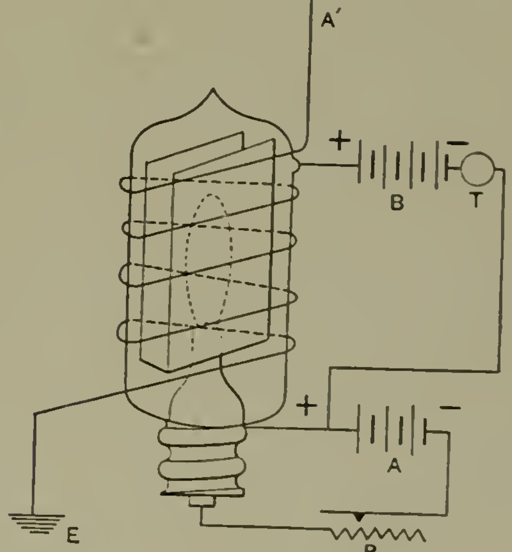


FIG. 6

is generally different from that required for the same oscillation frequency, when the interior wing is directly connected in the oscillation circuit.

In this condenser arrangement also the sound heard in the telephone changes its quality to an extraordinary degree, being of a dull, muffled nature rather than sharp and staccato. Signals of this quality are sometimes much more readily distinguished from the "static" disturbances which so frequently render wireless signals difficult to read. The operator has thus a ready means of changing the quality of the received signals to suit the conditions. This latter type of audion is the one found more serviceable in practice.

The audion may even be placed in the space between two plates of an air condenser in the oscillating circuit. A flat-walled type of tube is preferred for this arrangement.

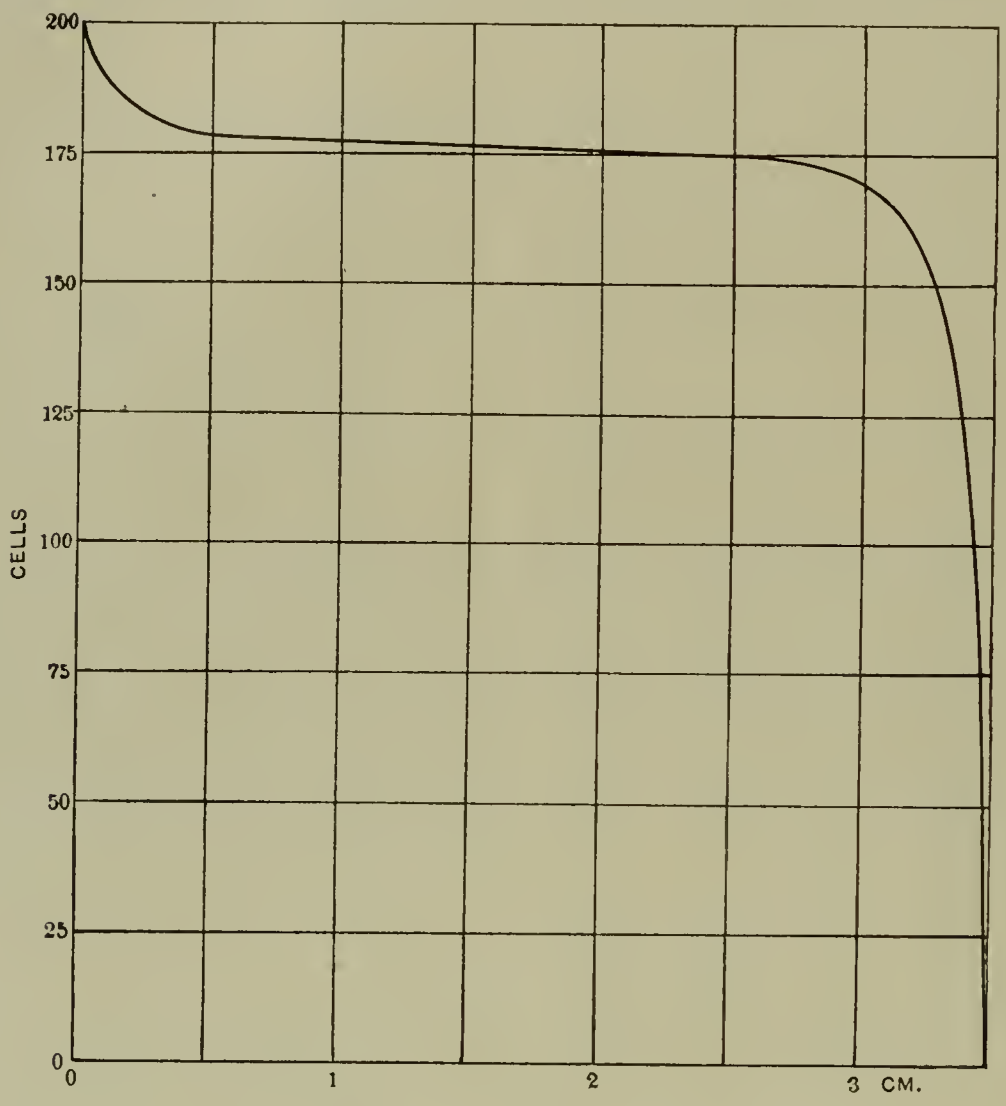


FIG. 7

Again, the electrical oscillation may be led through a coil of wire wound round the outside of the tube, as in Fig. 6, and not through the audion at all, or through a flat coil brought up close to the tube, with its axis perpendicular to the filament. In this arrangement it is chiefly the electromagnetic component of the passing oscillation which affects the motion of the ions within the vessel. The ions are readily influenced by a magnetic field.

By shifting the syntonizer connections from the wings to this helix, it has been possible to cut out completely signals from a transmitting station so near as to baffle all attempts with the ordinary tuner methods, and to bring in other relatively faint signals.

The audion has the further advantage of entire absence of adjustment in the receiver itself. It gives no evidence of fatigue under any conditions of use. Furthermore, it requires no protection from the violent impulses of the transmitter at its own station, whereas the sensitiveness of the electrolytic receiver is completely destroyed by one such violent impulse, unless its small electrode is protected by a shunting switch.

The writer has arrived as yet at no completely satisfactory theory as to the exact means by which the high-frequency oscillations affect so markedly the behaviour of an ionized gas. Fleming points out that when the cold plate of the Elster-Geitel tube is connected to the positive end of the filament, and the two put in a high-frequency oscillation circuit, only the positive half of the oscillation can pass from the plate to the filament across the gas. He uses the principle to rectify the Hertzian oscillations, and applies the unidirectional currents of the oscillations themselves to operate a sensitive galvanometer, or direct-current instrument, for quantitative measurements over very short distances.

When an independent external source of electromotive force is applied, in the manner described herein, the action becomes quite different. It then operates as a relay to the Hertzian energy instead of merely rectifying this energy so that it can be used directly to give the sense signal.

The audion, therefore, is tremendously more sensitive and available in practical wireless. A sensitive direct-current instrument in the *B* circuit shows a steady deflection varying not a whit, by increase or decrease, during the reception of strong "wireless" signals. An electrolytic receiver or "polariphone" under similar conditions would cause a great deviation in the deflection of a milliammeter, although the signals in the telephone with the electrolytic are not so loud as with the audion.

The writer has connected two audions in series in opposition in the oscillating circuit, each with its separate heating circuit, and still heard the signals in the telephone connected to the second audion equally well whether the wing in the first be connected to the wing or to the filament of the second.

When one of the tubes is unlighted, or if lighted its *B* circuit is open, no high-frequency impulses pass through it unless the wing and filament are very close together. When cold it acts merely as a conductor whose armatures are the wings and filament and whose capacity is extremely small.

Considerable stress is laid upon the potential gradient or "variation" layers which exist near the surface of the electrodes when the external applied electromotive force is considerable, for the reason that their existence serves to play a very important rôle in the response of the audion to minute high-efficiency oscillations.

If the velocity of negative ions is very large compared to that of the positive ions, the curve representing the distribution of electrical intensity between the two electrodes is represented by the following, which is typical:—

When ions of both signs are present in the gas and when the electric field is so strong that most of the positive ions are driven from the anode and the negative ions from the cathode (the filament), we will have an excess of cations in front of the anode and of anions surrounding the cathode.

It is seen that the variation in potential lies chiefly in the thin layers of gas in front of the two electrodes. It is convenient to speak of these regions as the "variation" layers. As Thomson points out, in passing from the inside to the outside of the layer of ionized gas we have to pass across a layer of electricity. This will produce a discontinuity in the electrical intensity equal to 4π times the surface density of the electrification.

There may thus be a great difference between the electric intensity inside the layer and that just outside. The potential drop across the layer is proportional to the square of the current; the falls of potential at the positive and negative electrodes are proportional to the squares of velocities of the positive and negative ions; and the velocity of the ions is proportional to the electric force acting upon them.

These variation layers at the electrodes of the audion make still more striking its similarity with the cathode-ray tube. In the cathode tube a sudden drop in potential, called the "anode fall of potential," occurs quite close to the anode; and in the layer called the Crookes dark space, or cathode dark space, there is a still greater fall in negative potential. But the voltages here are enormously higher than those in the audion. As the gas pressure in the cathode tube diminishes, the dark layer, or the cathode drop layer, becomes broader.

Schuster found that the thickness of the cathode drop layer increased slightly with the current passing through the gas; but Wehnelt found just the reverse. Both may be correct on different sides of some particular value of the current for which the width of this space is a minimum. This is interesting, in view of the fact that there is a certain current flux across the gas of the audion for which the response of the Hertzian oscillations is a maximum; supposing this response is a maximum when the width of the variation layer around the filament is a minimum.

Within the cathode layer there exist only negative ions, being shot off from the cathode. Right outside of this, in the region called the "cathode glow," ionization of the gas from collisions with these negative ions begins, and the width of the cathode dark space is about the range of the "mean free path" of the ions.

If a similar state of affairs exists around the filament of the audion, and if this mean free path of the cations coincides with the excursion of the corpuscles during one-half the oscillation period of the impressed Hertzian vibration, we might expect under these conditions a maximum effect of response to oscillation of the particular wave frequency. Or a similar effect might be expected if the excursion in question is that of an ion from the cathode across the gas up to the layer surrounding the anode.

The extent to which the sensitiveness of the audion is sometimes governed by a very slight change in the heating current, or in the potential drop across it, seems to lend plausibility to such an explanation. And it has been shown that in conducting flames at atmospheric pressure a negative ion acting under a potential gradient of 10 volts per mm. would travel approximately 1 mm., or a commonly found distance between the electrodes in the audion, in $\frac{1}{1,030,000}$ part of a second, which time interval is of the order of one-half the wave period of some of the longer oscillations used in wireless telegraphy.

For reduced gas pressures the natural excursion of the ion would be more rapidly accomplished, but its velocity can be governed within wide limits by regulating the applied electromotive force. When we send more current through the filament we increase the potential difference between filament and anode, as well as increase the heat. Both changes act to increase the ionic velocity.

In Humstedt's experiments, where a cathode-ray tube was exposed to high-frequency oscillations the width of the cathode drop layer, or dark space, diminished as the frequency of the oscillations increased, as if there might be some connection between the period and the time involved in the immigration across. And many facts observed in connection with the audion otherwise difficult to explain tempt one to suppose that here the degree of response is connected with the relation between the product of velocity of the ions by the distance between the electrodes, and the period or half period of the electrical oscillations received.

When the anode consists of two parallel plates instead of a cylinder there will be a maximum of positive electric density along their vertical edges. The more intense parts of the electric field will involve the larger number of ions, and on the anode these will generally be located at the vertical edges of the parallel plates, provided these are not too far from the filament.

With this type of anode a peculiar and sudden inflection point in the current-flux diagram, as the heating current is gradually increased or decreased, is noticed. The flux goes on increasing, then suddenly drops back to a lesser value; at the same time a click is heard in the telephone in the *B* circuit. Then as the heating current is still further increased the *B* flux is again increased. These same cusp points in the curve are obtained if the *A* circuit be kept constant and the *B* voltage is increased instead.

Similarly a click is heard when the flux current is being reduced from a higher value, but the location of the cusp on the curve of decreasing current is not coincident with, but lags behind, that observed when *B* is being increased. This second cusp point shows a sudden increase in the flux current, when the critical point is reached, to a value previously passed through. Naturally the sharpness of these cusp points can be smoothed out or quite obliterated by putting impedance in the *B* circuit in series with the telephone.

Fig. 8 shows the relative magnitude of these sudden alterations in

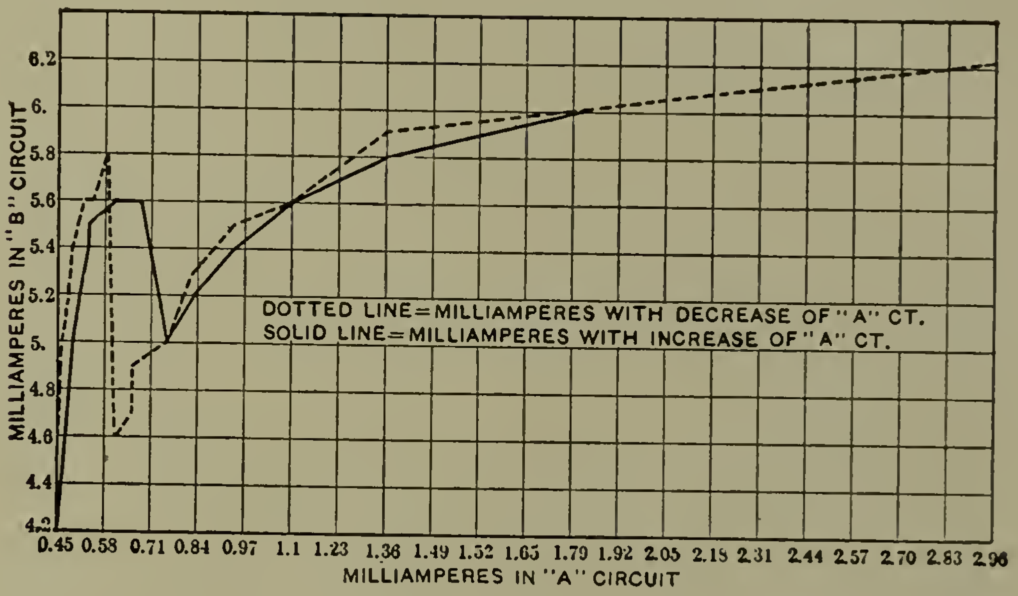


FIG. 8

the flux current obtained with a certain sample audion, and Fig. 9 the decided hysteresis effect, showing how the actual B current lags behind the increasing or decreasing electric field which produces it. This hysteresis effect is very like that obtained when the molecular structure of iron is altered under a changing magnetic field. Doubtless it is here due to a resistance of the ions to accommodate their paths and velocities to the impelling electric forces. The area included between the two curves represents the work lost in accomplishing this conformation.

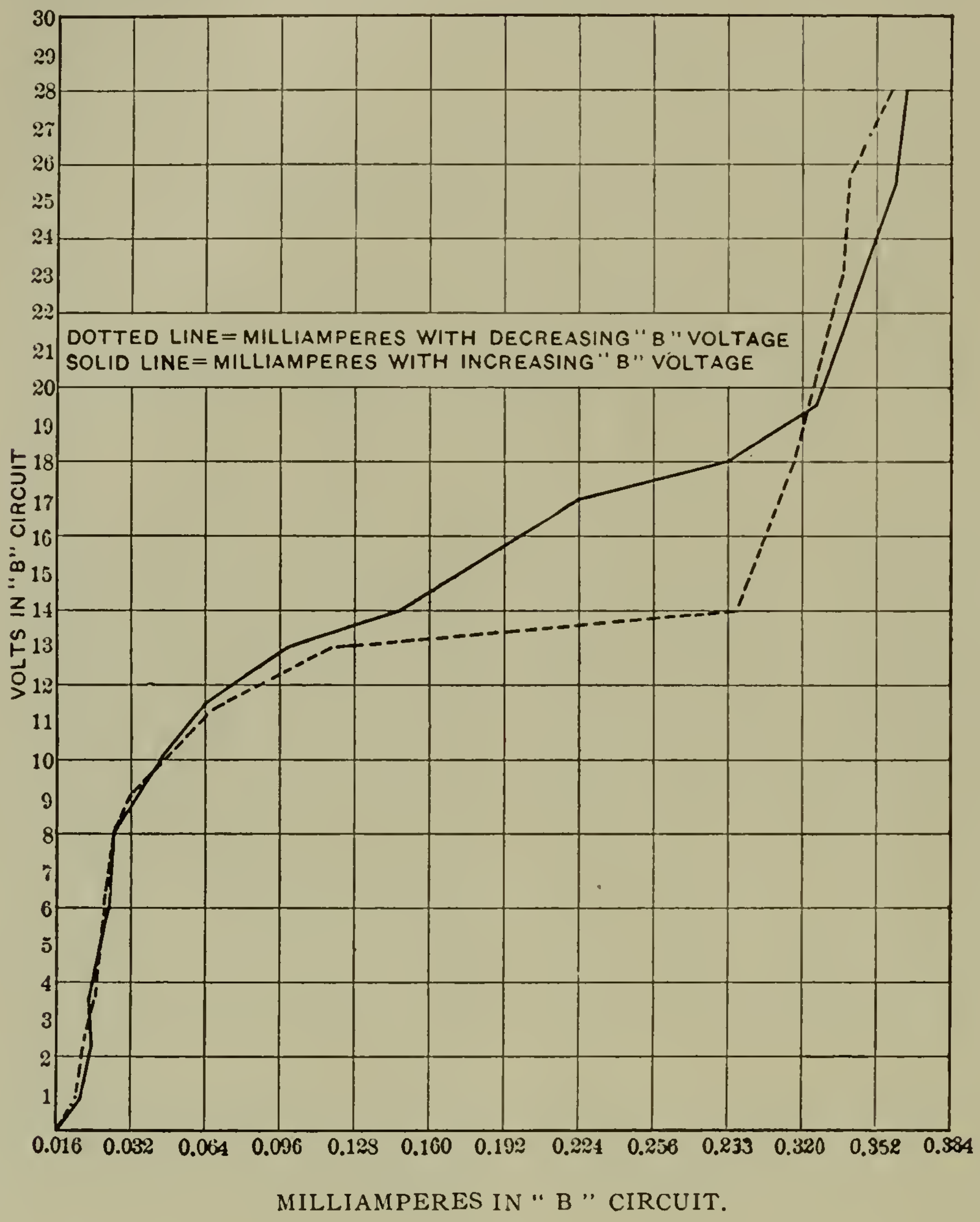


FIG. 9

These hysteresis curves are always obtained even though the anode is in the form of a cylinder or flattened cylinder without the vertical edges; but the reactive cusp points in the curves are never obtained save with the plane anodes.

Zeleny* has found a similar very curious hysteresis effect in the currents obtained from the ions from a platinum wire when heated and exposed to ultra-violet light. When the metal was cooling, these currents were greater than those for the same temperature when the metal was being heated. In this case heating the wire produces some change in its surface, possibly in the amount of gas condensed thereon or absorbed by it, from which it recovers very slowly.

As B voltage is increasing and A current is increased and decreased, the points at which the cusps occur on the increase and decrease A-B curves coincide more and more nearly, and at the same time these cusps become less and less violent. The hysteresis effect when the heating current is increased and decreased is less pronounced as the B voltage is increased. As shown in the curves for a large B flux, the two A-B curves for increasing and decreasing A current coincide almost exactly until B flux is reduced to a certain amount. They may again cross each other at a lower point of B flux, again diverge, and then coincide once more near their origin. These curves were all taken with audions of the double-swing type, which feature may account for some of the very peculiar characteristics observed during the investigations.

The filament is always at some part nearer to one wing than to the other. Hence the B flux is chiefly concentrated on this wing or portion of wing, like a beam of cathode rays. We may suppose that as the B voltage is increased, as when more heating current is passed through the filament, the flux is increased and spreads out over this wing until a new sheaf or "ray" of ions, starting off from the filament from another part or in a new direction, suddenly leaves that wing and takes by preference a shorter path to the opposite wing. We would suppose that a new path thus taken would first be located on one of the vertical edges of the wings parallel to the filament.

This sudden diminishing of the intensity or density of the original beam of ions may be accompanied by a decrease in the velocity of propagation of the ions, and thus the resultant flux be actually less than before. The reverse operation will occur when the B flux is being decreased from a high value.

When the anode consists of one wing only, no such reverse cusp-points, or reversals of the flux increment, have been obtained. With a single-plane anode, however, there is found a point at which the flux, if increasing, assumes a sudden increase in magnitude, representing an abrupt rise in the otherwise smooth flux-voltage curve, and the reverse when the current flux is being decreased.

These effects seem to relate to the increased values of the positive variation layers along the vertical edges of the anode which parallel the filament. The distribution of the charge upon the surface of the plate may be described as analogous to that of a thin film of liquid which coalesces and is heaped up along the edges, and from which, when the liquid is by any means drawn away, there is a sudden recession, the liquid, on account of the surface tension, letting go or taking hold of the edge all at once.

It is significant that just at a cusp point the sensitiveness of the audion to the Hertzian oscillations attains a marked maximum. Under the critical conditions then obtaining the slightest change in the applied electromotive force is accompanied by relatively great changes in the B flux.

In framing any theory of the action of electric oscillations in the audion, a variety of complex, contradictory phenomena are met with, exceedingly puzzling to explain. An

* Zeleny, Physical Review, Vol. XII., 1901.

example is the fact that a continuous-current instrument in either the *A* or the *B* circuit shows absolutely no change of deflection, either of increase or decrease, when *B* is large and the audion in its most sensitive condition.

If only the positive halves of the oscillations pass from anode to filament these should increase the reading of a milliammeter in the *B* circuit during the passage of a long series of wave-trains of sufficient intensity. Or else the negative halves of these oscillations might be expected to diminish to a greater degree the positive charge on the anode, and result in a diminution of the *B* circuit. Or if both of these acted equally and oppositely, no signal would be obtained at all, for the telephone diaphragm is utterly incapable of following such rapid increase and decrease in the *B* current, even if its impedance would allow these pulsations to pass through the circuit. Neither would the ear detect such vibrations.

If, on the other hand, the integrated effect of a complete Hertzian wave-train were either to increase or decrease the *B* flux, a long succession of such effects, all of which must be of the same sign, ought to cause a change in the needle's deflection, as when a long Morse dash is sent out from the transmitting station. We have no reason to suppose that one wave-train, the result of one spark, would produce a momentary decrease in the *B* flux, indicated by a click in the telephone, and that the next succeeding wave-train from the next spark would cause an opposite increase in the *B* flux, and another similar click in the telephone. Such action would, of course, explain why a loud sound in the telephone might not be accompanied by any change in the sluggish ammeter reading, similar to the case of the magnetic detector.

The following explanation of the phenomena which seems to account for many of the peculiarities of this paradox has been suggested. It should be remembered that if the negative half of the electric oscillation cannot pass through the gas from cold anode to the filament, the audion electrodes during that half-period will act merely as the two armatures of a condenser. Even when close together, their mutual capacity, when the gas is cold, is exceedingly small, and only a very small positive charge can be held bound on the filament; or if there are sufficient free positive ions in the hot gap the complimentary positive charge will be held just on the outside of the "variation layer" at the anode.

The falls of potential across the variation layers at anode and cathode are proportional to the squares of the velocities of the positive and negative ions, and the ionic velocities are proportional to the electric forces acting upon them. Supposing, then, that during the positive half of the electric oscillations the velocity of the positive ions is increased at the anode layer, and during the other half period the velocity of the negative ions is increased, due to the changes in the electric force acting upon them. Then, regardless of the sign of the change of the velocities, the potential drop across the variation layers (which varies with the square of these changes) will be increased during the entire passage of the oscillation train.

The layer will act during this interval like a condenser, the potential drop across which is momentarily increased, which momentary increase will disappear with the passage of the wave-train. It will be as if the plates of a charged air condenser were suddenly further separated and then brought suddenly back to their normal positions, or as if the specific inductive capacity of the dielectric were decreased and then increased. This operation being repeated for every spark at the transmitter, a listener in the telephone in the *B* circuit will hear a sound whose pitch is exactly that of the spark, while a milliammeter in that circuit will show no variation in its deflection.

As the fall of potential across the variation layers is proportional to the square of the current passing and to that of the impelling electric force, it is readily understood how, by regulating the heating current and the *B* voltage, an optimum value of the electrode drop may be obtained for which the effect from any given received impulses will be a maximum. Also how by varying the distance between the electrodes the sensitiveness of response may be regulated.

Thomson states that the current between two plates for a given difference of potential varies inversely as the cube of the distance between the plates up to the saturation-current stage. But in the case of the audion, where the cathode is an incandescent filament, the law seems to be quite different. Thus, for two anodes of equal area, one approximately four times as far from the filament as the other, the two currents were as 21 to 8. The flux here varies more nearly as the inverse distance.

The potential difference required to produce saturation is proportional to the square of the distance between plates and to the square root of the intensity of ionization. This latter depends on the temperature of the filament.

In the case of the parallel plates, only one of which is incandescent, or if both are heated, but below yellow heat so that only ions of one sign (positive) are present and carrying the current, then this current, as Thomson shows, is:—

$$i = \frac{9 R V^2}{32 \pi d^3}$$

where R is the velocity of the ion under unit electric force, V the potential difference, d the distance between the two plates. According to this formula, the current varies inversely as the cube of this distance, But this formula will hold only when R is independent of X, which it will not be when the temperature through the space is not uniform. It holds also only for currents that are small compared with their saturation values, for the saturation currents depend not upon the velocity of the ions, but upon the number of ions produced in unit time at the surface of the hot electrode.

But in the case of the audion with small potentials, the closer the electrodes are together the more rapidly will the *B* current increase as the potential drop is increased. The trajectories of the ion are shorter, and they, therefore, undergo fewer collisions, reunions, and retardations when the electrodes are close together.

In an audion where the anode is far from the filament, the saturation current is not attained with the *B* voltages used in practice. We sometimes have instead its inverse counterpart, a saturation voltage, so to speak. As shown in the curve, at potentials from 10 to 18 volts a slight potential increment is accompanied by a very large increase in flux. And within these limits the sensitiveness of electric oscillations may be a maximum. The cusp points when present are generally found near these points of inflection in the flux-voltage curves.

In some cases a remarkable lag or "creeping effect" is observed at this saturation stage. In one instance, the milliammeter needle crept slowly up, after *B* was raised to 14 cells, from 18 to 26 divisions. The current flux required something like 15 seconds in this instance to attain its full value. The filament in this case may have been undergoing some change which caused it slowly to discharge more and more corpuscles until that stage was reached where the recombination of oppositely charged ions in the gas exactly equaled the output of negatively charged ones from the incandescent surface. Sometimes this creeping is accompanied by a loud frying sound in the telephone.

MAGNETIC EFFECTS

Thomson shows that at low gas pressures and high ionic velocities the ions, when placed in a strong magnetic field, will travel along the lines of strong magnetic force; but when the product of velocity and field is small the ion moves parallel to the electric force. If both magnetic and electric forces are uniform the ions, both positive and negative, will move in the same direction and perpendicular to both E and H. When the electric field is not uniform, but radiates from a point, and the magnetic field is uniform, the ion will describe a spiral traced on a cone of revolution whose axis is parallel to the magnetic field.

If the direction of E and H coincide, the path of the ion itself is a helix of gradually increasing pitch, with its axis parallel to the lines of magnetic force. The radii of the spirals will be small compared to the length of the mean free path of the ions. This is especially true for the negative ions, even when the motion of the positive ions is but little affected by the magnetic field.

When the lines of magnetic force are perpendicular to the discharge in the cathode-ray tube, the magnetic field at all pressures retards the discharge and diminishes to a considerable degree the great drop in the electric force which occurs in the negative glow.

In general, it can be assumed that in a strong magnetic field the ions tend to follow the lines of magnetic force. The smaller the velocity of projection the more nearly does the path of the ion coincide with a line of magnetic force. In cathode-ray tubes the boundary of the negative flow may coincide with the lines of magnetic force.

In the case of the audion, if the lines of a strong magnetic field pass through the gas parallel to the plane of the anodes, a marked reduction in the flux is obtained, sometimes amounting to 20 per cent. This effect is greater when the south pole of the magnet is nearest that leg of the filament which is attached to the negative terminal of battery A.

The negative charge on this leg is, of course, greater than on the other, for the negative charge on the other is the resultant of the negative potential of battery B and the positive potential of battery A. And when the lines of magnetic force are so directed as to tend to sweep some of the negative ions off from the parts of the anode nearest to the filament leg which carries the greater negative potential, the reduction of the flux across the gas will be the greatest possible. Hence the magnetic polarity observed.

If the filament extend above the top of the anode, say for 0.5 cm., then a magnetic field parallel to the filament legs may tend to force certain lost ions into a downward trajectory so that they will strike upon the anode instead of passing off above it. In this case only is an increase in the B flux observed as a magnet is brought up to the audion.

In general, the flux will be diminished by the magnetic field. When the magnetic lines pass perpendicular to the plane of the wings the negative ions which are traveling in the direction of the magnetic force, from filament to wing, will be accelerated, but those originally traveling out from the filament in the opposite direction will be bent around or deflected from their direct paths; so the resultant will be a decrease of the total current flux.

When the field is intense, a marked frying or hissing sound in the telephone is heard, especially with the two-wing anode, and when the magnetic force is parallel to their plane and thus affecting mostly the ions which are streaming towards their vertical edges. In the hissing arc parts of the arc are in rapid motion in the unstable portion around the edges of the positive terminal. Possibly also the presence of oxygen in the gas centres into the phenomena here as it does in those of the hissing arc. As the magnetic field lengthens the arc, so here it lengthens the paths of the ionic discharge.

The hissing is much more violent when the surfaces of the anode instead of being plane are punched full of little holes, whose ragged and protruding edges offer greatly increased opportunity for the ions to travel irregularly under the combined forces of the magnetism and of the electric charges heaped up at all such points and edges. In this particular audion a great range of singing or squeaking sounds could be obtained as the heating current was varied. Where the velocity of the ions is a maximum their deflections by the magnetic field will be lessened.

If the B flux is too great to give maximum sensitiveness of response, bringing up a magnet to the audion will increase the strength of the wireless signals, because of the reduction of the B flux. Or if this flux be already below the optimum, then the presence of the magnet may decrease the sensitiveness. This effect may be more pronounced for one wave frequency than another, in which case the audion can be attuned by regulating the magnetic field to which it is subjected.

Consider the case where the electric oscillations instead of being introduced into the audion through its interior anode are brought up to a metal plate outside a vessel. Electric displacement currents instead of conduction currents must then act upon the ions within the vessel and on the charges upon the electrodes.

Now in the case of an electromagnetic wave, where H and E are perpendicular to each other and to the direction of propagation, Thomson shows that if the product of $H \times e$ is large (e being the electric charge on a carrier) the average velocity of the ion parallel to the direction of E is zero, and the wave will carry the ion along with it. When, however, $H \times e$ is small (no external magnetic field), the effect of the Hertzian wave will be to superimpose on the undisturbed motion of the ion a small vibratory motion parallel to the electric force in the wave and thus perpendicular to its direction of propagation.

A very convenient form of audion for investigating the relations which the distance, area, etc., of the electrodes bear to its response is had by using a pool of mercury for the anode. This is conveniently held in one or more pockets blown in the walls of the glass vessel, and the filament so placed as to pass closer to some than to others.

Quite frequently the writer obtained with this arrangement two maxima of sensitiveness to the same transmitter, the filament-heating current remaining unchanged; thus, one maximum for $B = 12$ volts and a second for $B = 18$ volts. Again, the sensitiveness is maximum when the mercury surface is as near as possible to the filament. When a globule has rolled out of its pocket, exposing a new surface for the anode, sometimes half a second elapses before the sensitiveness is again restored. This form of mercury tube is especially sensitive to the influence of a magnetic field.

The optimum or critical voltage of B becomes less after this audion has been heated a little time, as though the heated mercury vapour began to act to increase the conductivity of the gas. This critical voltage keeps reducing as the vaporization proceeds, and a sudden jar on the tube can bring this down, one cell at *B* at a time, accompanied by a loud click in the telephone at each reduction. Sometimes a similar reduction of the *B* flux amounting to as much as 25 per cent. can be obtained with the double platinum wing type of audion, by striking it smartly, or a sudden increase in the flux may be obtained.

The heating current when a large anode surface is used is less than that required to produce the same degree of sensitiveness with a small pool of mercury as anode. In general, the flux is quite proportional to the area of the anode, other conditions remaining unchanged. A mercury arc also may be substituted for the filament, but such an arrangement is apt to be noisy in the telephone.

When the Hertzian oscillations are passed through the filament instead of through the gas, they require to be of great intensity to give any response whatever. Any results from the added heating effect which they may contribute to the filament are quite insignificant. The response when audions are connected up in parallel, or series, is always less than for one used alone.

In a tube whose two-plane anodes are fitted on hinges and backed with small iron disks so that their distances from the filament can be regulated by an external magnet, the response to a long wave-length is greatest when this distance is the greatest possible; while to a wave-length of about one-half this the response is decidedly better when the wings are nearer to the filament. Of course, the *B* flux is greater in this latter case, other conditions being unchanged; but the selective quality in this tube just described seems to be due to the regulations of the distance between anode and cathode rather than to other factors.

The manner in which the audion should be located in the oscillating circuit, as well as many other considerations, shows conclusively that it is a "potential-operated" rather than a "current-operated" relay receiver. At the same time, its advantageous sluggishness of action, as explained above, renders it additive in its response to the energy of an entire wave-train or even of a series of wave-trains. Hence its excellent and marked selective qualities.

A large number of experiments have been carried out with a view to reducing the filament heat necessary to give the enclosed type of the audion the extreme sensitiveness which now characterizes it. This is now attained at normal brilliancy of the filament, or a little below; never at excessive heat. Thus the life of an audion should be that of an incandescent lamp of the same class of filament and voltage.

Filaments have been coated with alkali metals or salts, or vapours of these introduced into the tubes. Experiments along these lines with various dissociable gases are being pushed with gratifying promise of our soon being able to achieve the present marked sensitiveness even at red heats; or of still further multiplying the sensitiveness.

Radioactive compounds, applied, for example, between juxtaposed metal disks and heated, give little encouragement. At the low voltages used no increase of conductivity by their means has been observed, although Swinton has found that a radium-coated cathode in a cathode-ray tube has a marked action in facilitating a luminous cathodic discharge, when the cathode is heated to redness. The mere presence of radium salt in the tube is insufficient to produce the effect.

Spontaneous ionization, that is, the ionization independent of the electric field, as, for example, that produced by the X-rays, does not increase the current flux. Only the ions produced by the electric field itself close to the cathode, and by the heat of the cathode, is effective.

It is required that the audion be made with scrupulous care; a trace of impurity in the gas may produce surprisingly large effects in the potential drop across the variation layers. The presence of a mere trace of moisture may cause great difference in the behaviour of a tube.

In all this work a bewildering host of new and puzzling phenomena is continually encountered. By its nature clean and pretty, fascinating in its ever new phases, gratifying in the efficiency with which it responds to the difficult demands of a new and intricate art, the audion combines infinitely delicate matter and forces, at once offering rich fields for study to the physicist and delight to the practical man.

DISCUSSION

The discussion following the reading of the paper was opened by Dr. M. I. Pupin, of Columbia University. Dr. Pupin said it seemed to him that in the line of the detectors of wireless waves the number of detectors seem to be increasing indefinitely, good, bad and indifferent, of course. If we are going to have a new name for each new detector and a new name for everything that comes up in the course of the development of the new art, pretty soon the science of electricity and electrotechnics will be a maze of new names, and learning the names will be much more difficult than learning the facts connected with these arts. For that reason he was opposed to new names, and although Dr. De Forest was very enthusiastic about the beauty of the name Audion, the speaker was not very much impressed by the name. It was a bastard,—a Latin word with a Greek ending to it. If he had said Acouion it might have been better, but more difficult to pronounce. In Prof. Fleming's book dealing with wireless telegraphy, he also indulges in the coinage of new words, Greek words, and instead of calling a thing a detector, he calls it a cumiscope (?), a wrong word, because it is grammatically incorrect.

The instrument described is certainly a brand-new wave detector used in actual wireless telegraphy. The physics of the thing is old. It was Hittorf, who, over, fifty years ago, discovered that in a vacuum tube very high electric tensions would produce no perceptible discharge, but that the heating of the cathode facilitated the passage of electricity to such an extent that a small electromotive force, a few volts, would produce perceptible current. The speaker thought that the first observation of this kind. After that the number of men who engaged in this branch of most fascinating and interesting research was legion. The literature of the subject is very well given in J. J. Thompson's book on "Discharge of Electricity through Gases."

The speaker had been lately very much interested in the subject, because one of his colleagues, Prof. Tufts, of Columbia University, has made some very interesting investigations in that field, particularly in the passage of electricity through gases at ordinary pressures, a subject to which Dr. De Forest devotes some attention in the first part of his paper; but, for reasons which are evident from the paper, Dr. De Forest abandons this form of wave detector, because it is variable, of course, and refers to the vacuum tube. Dr. Pupin thought that a very clever step indeed, because one can see at a glance that this phenomenon, which the author first observed in connection with the passage through gas at ordinary pressures, flames of arc lamps, etc., should exist also in vacuum tubes, and that one would expect a very much greater steadiness and reliability, and that, of course, is one of the highest desiderata in any technical work, particularly in wireless telegraphy. In this Dr. De Forest seems to have been very successful.

Dr. Pupin would have been very glad if Dr. De Forest had given a brief historical account of the subject, and then a brief statement of the physical theory of the whole thing. He thought the paper would have been very much more easily understood by those who are not well acquainted with this part of electrical science. He thought the subject somewhat more outside of the ordinary line of work,— it is a new subject, a subject that has been, so far, mostly in the hands of physicists and not electrical engineers. He hoped that Dr. De Forest would, in the final publication of this paper, contribute a brief history and a brief statement of the physical theory of the subject for the benefit of the members of the American Institute of Electrical Engineers, who are not all of them physicists.

As Dr. De Forest states frankly, the explanation of the phenomena that one meets with when he tries to make a wave detector, the complicated and complex phenomena is very large, so that it is almost absolutely impossible to form a complete physical explanation of the thing. What we have there is the hot electrode from which negative ions recede, and then we have the cooler plate, which is negatively charged, is negative with respect to the hot anodes, and we have electrical tension applied to these points and a leakage current. We call it a leakage current for want of a better name; it is an electrical current.

Now, that electrical current is steady, according to Dr. De Forest, and that, in fact, is the most remarkable point in his paper; it is steady under all conditions, no matter whether electrical waves strike the oscillating circuit of which the tube is a part or not. It is steady as far as a milliammeter can tell. It is not steady as far as the telephone can tell. Well, now, if the effect of the Hertzian waves is to produce a uni-directional current, or rather, if the effect of the wave is to rectify the Hertzian waves, to let either the positive or negative parts of the wave pass through unhindered, why should we be expected to perceive that in the milliammeter? We do not perceive it, and, therefore, we cannot suppose that these waves are rectified.

The only other thing we can guess as possibly happening is that the oscillation passes through the whole circuit, but on account of some effect upon the gaseous part of the circuit, the resistance, or the diminution or increase of some of the other reactions, the original current is strengthened very much at certain intervals during one-half of the waves and weakened during the other half, or strengthened during each side of the wave. That, as Dr. De Forest points out, is also impossible to believe, because the oscillations being so rapid, could not very well pass through the winding of the telephone in the first place, and, in the second place, could not be expected to produce a very large magnetic effect upon the diaphragm, because magnetism and demagnetism of the permanent magnet in the telephone would not follow these very rapid oscillations. That seems to the speaker to be one of the most difficult points to understand in the paper.

When a man discusses a paper, of course he always talks on the point he understands least. That seems to be the most important point, and generally in the development of human knowledge, in our learning of anything, the point we cannot understand is the most important point, because as soon as we get over it we advance our knowledge, we advance the art. Whoever succeeds in explaining that point in Dr. De Forest's paper would, in all probability, advance the art.

The apparatus operates, that is all right; so far, so good; but why does it operate? That is the point. To explain why it operates an investigator must explain that point. That is the stumbling point in the whole thing. Why does it operate? It would be presumptuous on the speaker's part to offer one, even if he had any to offer, because a man who, on short notice, reads a paper and thinks over it for a day or two only, cannot be expected to know as much about it as a man who has worked on the subject for several months. If Dr. De Forest cannot explain it, the speaker certainly could not; but he had one suggestion to offer, and that was this: He had employed a telephone in his work for quite a number of years for detecting faint sounds, faint differences of potential, and faint currents, and had found the telephone one of the most tricky instruments. It will lead one to draw false conclusions, and, if one does not look out, it will have the laugh on him some day, because if one sleeps over his work for several months, or a year, he discovers that he is to be congratulated on the fact that he did not publish results that might have been published,—the telephone has misled him.

The most misleading point in the telephone is to distinguish between electromagnetic effect and electrostatic effect. The sensitiveness of an ordinary telephone has been estimated variously from ten to one-millionths of a volt. Now that is a very high degree of sensitiveness. It would be if it were correct. It is not correct; the telephone is not as sensitive as that, and Dr. Pupin believed that those who make measurements did not measure the right thing. If they had measured the current when they were determining the sensitiveness of the instrument, they would have found that the thing measured was not the current passing through the telephone coils, but that it was the current which went through the body, all along the floor, the leakage current, which affected the magnetic current in the telephone which produced the sound.

He had been misled that way quite a number of times; so that today, whenever he saw anyone using the telephone in his measurements in his work, he always looked askance and shook his head, and asked himself, "Has not this man been deceived in his calculations?" He did not want to imply that Dr. De Forest might have been deceived in his measurements; he only wanted to say when it is said we hear the sound, the question arises in his mind. What produced that sound? Was it the variation of the current which went through the winding of the telephone, or was it the variation simply of the potential in the whole room, in his body, and in the windings of the telephone?

That seemed to him the only suggestion he might offer, and it is a suggestion in the line of which he could see an explanation in the most puzzling point in the paper. He hoped that there was nothing in the suggestion, and that the point was a real physical one, that we have actually a sound in the telephone without a perceptible variation of the current, and that the sound in the telephone is produced, not by the electrostatic effect, but simply by a new effect; because if it is not an electrostatic effect he was sure it is a new effect in the investigation of which we will all get new light upon the whole thing.

Percy H. Thomas said that while he knew very little about practical or theoretical wireless telegraphy, all must be interested in such a paper as this, especially if it is going to lead to new and practical developments. Apparently we have come across another example of the new theory in electrical science,—an apparatus depending on corpuscles or ions. It looks as if in the future this would be one of the most important developments,—the knowledge of ions, the phenomena of corpuscles.

This apparatus will probably not introduce any fundamentally new principles. At the present time people are hardly agreed, the speaker thought, on the exact nature of electricity, corpuscles and ions, but there are a good many things agreed on which we can use in trying to understand the various phenomena of this character. The easiest way to look at it is to consider that electricity is either corpuscles or is connected directly with corpuscles. By corpuscles or electrons he meant those very small molecules, approximately one-half part of hydrogen atoms. These molecules, when at rest, are static electricity, and as such are attracted by an electrostatic charge, sensitive to an electrostatic field, and not affected by electromagnetic influences. When, however, these molecules or particles are moved rapidly, and they do move extremely rapidly, anywhere from slow velocities to the velocity of light, then they are the equivalent of electrical currents, and as such are subject to the influence of magnets.

This simplifies the conception of the curious relation of electrostatic, electromagnetic and ionized particles. These particles might be looked upon as comets, or planets, or suns in space. When they are in a vacuum they move about under the influence of the various forces, electrostatic or electromagnetic, as they may be, in straight lines or curved lines, as the laws which govern them may call for; but if they are in air or other gases, their free movements are impeded, they bump against one another, the molecules come in contact with the gases, and they are unable to go in the direction to which they are reaching, or they attach themselves to some such particles and form an aggregate. In such case they are lost. In a perfect vacuum these particles are perfectly free to move, and such a vacuum can be obtained so that the molecules may move in perfectly straight lines and in great velocities, and these are the types of apparatus to which they are mostly suited.

As Prof. Pupin had said, that is the way to make use of corpuscles, if you want to use them; get them into a vacuum where you can control them, but these corpuscles or electrons do not exist in a free state ordinarily, any more than sodium or chlorine, or other materials do. If you want to use them you must produce them. There are many ways of producing these corpuscles. They naturally are associated with matter. They are connected with the atoms or molecules, presumably the molecules, and they have to be forcibly separated.

They are frequently separated from air gases, and that is done, for example, in the X-ray tubes, the waves that come from the X-ray tube, or Crookes tube, or it can be done as the paper states, by letting ultra-violet light fall on certain materials. They can be produced by the arc or flame, as in the original audion, and in many other ways, and can be produced from certain liquids, as in the Crookes tube perhaps, at any rate, in the Cooper-Hewitt lamp, and they are produced in great quantities, probably from the electrons themselves.

Now, in the audion we have a means of producing ions. In the first place, we have a vacuum, which allows a more or less free movement. We have a means of controlling and directing these ions, that is, this additional battery electromotive force, and then we have, further, the waves which come in on the transmission circuit, which, in some way or other which we do not understand, so affect the action of the corpuscles as to make a sound in the telephone.

The speaker had discussed corpuscles as though they alone were the important action here, while in the paper ions are spoken of. Perhaps it is impossible to say whether it is the corpuscle itself or the corpuscles attached to one portion of the gaseous molecule which is there, and forms an ion. The determination as to which it is, is, perhaps, not very important. The explanation that is suggested for the curious action of the telephone, that it depends upon a virtual change of dielectric, is certainly an ingenious one, and might turn out to be the correct one. There is one question he would like to ask Dr. De Forest. Did the author presume that the action depended on the ionization of residual gases within the vacuum, or was the vacuum so perfect that the ions or electrons came from the electrodes themselves? There might be a difference in the result.

Dr. De Forest, in reply, said he thought it due to the ionization of the residual gases; the gases still live in the lamp, because the vacuum is only that which obtains in all incandescent lamps.

Mr. Thomas, continuing, said it would at least be largely connected with the residual gases. We have a number of illustrations of the action of these particles; in the first place, there is the Geisler tube, in which, by a strong electrostatic force and high potential, corpuscles are either detached from the electrodes or are produced in the residual gases, which are purposely left in the Geisler tube, or by both methods, so that there is an agitation of the atoms of residual gases in the vapour space which gives light. The different character of the atoms gives different colours of light.

In the Crookes tube practically the same phenomenon exists, except that the residual gases are extracted and the electrons or corpuscles are forcibly driven through the tube again, but give no light, because they meet no obstruction unless there is some fluorescence in the tube upon which they impinge and give light; or the tube may be used for the purpose of getting waves of some other form.

The X-ray tube has the same phenomenon, only the waves impinge on some surface common with the X-ray tube in surgical work or otherwise. The ordinary electric arc is presumably the forcing of a large number of these corpuscles from one electrode to another, having them come in sufficient force and numbers to crowd back the atmospheric pressure and keep the gas to one side. A large number of them escape to the surrounding air, which produces an ionization of the air itself, giving a number of free corpuscles floating around in the neighbourhood.

The Moore vacuum tube is similar to the Geisler tube; the Cooper-Hewitt apparatus is of the same general type of phenomena. There is a drawing of a large number of corpuscles from the negative electrode, which, in the case of the Cooper-Hewitt lamp, excites the vapour in the parts so that it will give light of the proper ray. In the Cooper-Hewitt type of apparatus there is this difference: that by virtue of the vacuum and the large quantity of corpuscles, it requires very little electrostatic pressure to force them from the electrode. In the Crookes tube, however, where the number is very much smaller, it takes a great deal of electrostatic force to drive the corpuscles from the solid electrode. That point is presumably also another example of this same type of phenomenon.

Sewall Cabot asked Dr. De Forest to explain two points. He stated, "The audion, to a greater extent than any other responder, is self-tuned." The speaker asked if that condition of self-tuning referred to being able to alter the electrostatic capacity of the audion, *per se*, in the resonant circuit, opening the inductance and capacity, which would be a tuning circuit, and, therefore, altering the tuning of the circuit by altering the electrostatic capacity of the audion, or did it simply refer to the tuning of the spark frequency, that is, by changing the battery potential, having the audion more or less responsive to relatively slow frequencies, of, say 400 a second, which might be said to correspond with the spark frequencies?

Dr. De Forest, in reply, said that both effects were present. Where the tuning of the audion is regulated by changing the resistance between the two electrodes, as in the last case described, where the two wings are hinged and drawn to and taken from the filament by a magnet, we have there the change of capacity intensity; in the other case, where the resistance between them and the heating current or the filament remains unchanged, we merely vary the potential across the gap.

It is rather difficult to explain it on the ground of merely changing the capacity. It is, of course, varied by the variation of potential difference, but even though the wave frequencies of the two transmitters are as nearly the same as we can make them, one spark being 125 per second and the other 60 per second, the change of the battery *B* from 12 to 14 volts makes all the difference in the world between the resistance of the audion to *A* or *B*.

Dr. De Forest thought it due rather to the integrating effect, and would not attempt to enter into a greater explanation than that. There is some effect from the period of excursion of the ion across the gap, or on the total energy required to produce the resistance in either case; in one case the ions are driven by considerably greater potential than in the other case; in other words, both effects spoken of are present.

Mr. Cabot, continuing, said it was true that the capacity of the audion may be changed through relatively large values so as to produce a considerable difference of resonance in the closed resonant circuit across our condenser. The capacity of the audion would presumably be very small with regard to its capacity to bring the closed resonant circuit to the point of resonance.

Dr. De Forest said the capacity of the audion measured in that way was very small; a very small condenser put in shunt across it took away the resistance.

Asked by Mr. Cabot if a considerable separation of the wings would not relatively change the tuning of that specific closed resonant circuit greatly, Dr. De Forest said no, not greatly.

Mr. Cabot, concluding, said that the principal effect in tuning, then, is with regard to the spark frequency.

As to the point that the direct-current milliammeter or direct-current galvanometer, or whatever the instrument was, shows no change, J B. Taylor could see no reason why it need be expected to. As he understood the action of the electrolytic detector, there is a film formed which breaks down. A direct-current instrument will not show anything; the telephone shows it, and if you put in a sensitive alternating-current instrument you will see it there. Just what determines these things he could not say; as a rule, in apparatus of that class what is heard is more or less peculiar to it; one gets a distinctively difficult quality of tone. If there was a distinct quality of tone, he thought it due to the fact that the thing had its own pitch.

E. P. Thompson took up the point referred to by Prof. Pupin as the most important one from the physical standpoint, in reference to the electromagnetic action and static action in the telephone. Some time ago he was puzzled with that question. He believed that the electrostatic feature has something to do with it. In order to prove this, he made a receiver and left the electromagnets out, and closing one end up put two terminals there so that they could be adjusted, so that they were practically alike, and in that receiver the sound was produced, an exact reproduction of the transmitting spark. It was not very sensitive, it could not be used on the field, but could be used for a matter of a few feet. When we resolve that down, is it anything more than the old Hertzian receiver, consisting of two terminals forming a spark gap? That is all it is. So that the telephone feature will have to be explained not only on the principle of electromagnetic action when used in wireless telegraphy, but on the principle Prof. Pupin suggested, of some kind of electrostatic action, or a combination of the two.

One of the points which struck F. J. Vreeland was the striking similarity between some of the phenomena Dr. De Forest had pointed out, and certain functions that occur in the electrolytic cells. We know it is quite the fashion now to point out the analogy between the behaviour of ions in the gas and the behaviour of electrons or ions in the electrolytic solution, and though these analogies will not always bear the test of strict scientific scrutiny, they are very suggestive sometimes. Dr. De Forest had pointed out that in the audion there was a production of ions in the neighbourhood of the hot filament, and also showed that these ions were concentrated mostly in the vicinity of that filament. The ions in this case were produced by the heating of the filament, but if we take an electrolytic cell, for example, a pair of platinum electrodes immersed in acid, and connected to a source of electromotive force across it, we will also get a collection of ions on the anode and a collection of opposite ions on the cathode. The electrodes are said to be polarized.

The distribution of potential in the electrolytic cell is somewhat analogous to the vacuum tube of the audion, and we can reproduce some of the phenomena that Dr. De Forest had called attention to. For example, Dr. Pupin discovered years ago that if we take such a cell with very small electrodes, connect the battery in series with it, polarize it, then that combination of cell and battery is capable of rectifying an alternating current. The current will flow through it in one direction, but it will not flow through it in the other.

Now, that is a rather close analogue of the arrangement of Prof. Fleming's, to which Dr. De Forest has called attention. In Prof. Fleming's vacuum valve, he took one of these hot filament tubes and connected it in series with the source of electromotive force and a galvanometer, and he got a rectification. He explains that phenomenon by the fact that the negative corpuscles being so much smaller and more mobile, and having a higher velocity, are more easily set in motion than the positive electrons which are gathered at the other terminal, and consequently the current will flow more readily in one direction than in the other.

Now when we come to the polarphone receiver, if Dr. Pupin had been in the position the speaker was in when he coined that name, he would have found it awkward to say

"An electrolytic wave detector which operates by impinging Hertzian waves." Polariphone is not quite so beautiful as audion, but it suggests the fact that the thing works by polarization. In the polariphone cell there is a very minute anode, and usually a larger cathode, and that cell is polarized by a dry battery. As you increase the voltage across the cell, at first you get no current, but when you reach a certain point here the current will begin to flow, very minutely, it is true, but still it is a current, and that is at a point below the voltage ordinarily known as the decomposition voltage of the electrolyte, which is about 1.7.

This current commences at a point below that, and will gradually increase until it reaches a point where it runs almost parallel, giving a large increase of current for a small increase of electromotive force, and finally reaching a critical point where the curve turns over and you get a very large increase of current for a small increase of electromotive force. If you polarize the cells for about that point, it is very sensitive to electrical oscillations, just as the audion is. These oscillations pass through the cell, depolarize it, and as the result of the depolarization the counter electromotive force is diminished and a large current flows from the battery and gives impulse to the telephone.

Comparing that with Dr. Pupin's rectifier, we get a very similar analogy to that which exists in the comparison of Dr. De Forest's audion with Fleming's vacuum valve. It is vastly more sensitive, and exhibits a phenomenon which is not rectification,—it is rather a relay effect, such as Dr. De Forest ascribes to the audion.

As to the question why the current does not affect the ammeter, Mr. Vreeland would like to ask Dr. De Forest if it is absolutely certain that the current which affects the telephone is not a uni-directional pulsating current. The reason he asked this was that in the polariphone receiver by suitable adjustment a similar phenomenon is obtained, and a very distinct and even loud signal is obtained without any increase of current which will affect the instruments ordinarily used for measuring these currents.

Of course, the telephone is an exceedingly sensitive instrument, and if we discount the figure that Dr. Pupin suggests, suppose we say it is only sensitive to the millionth of an ampere. That is a conservative estimate. Telephones are certainly sensitive to that current. Current of a millionth of an ampere would not affect any of the instruments which one would be likely to use in measuring such an effect.

Mr. Vreeland asked if it were not possible that there was a uni-directional polarized current sufficient to affect the telephone and not sufficient to affect the instrument you were using.

Dr. De Forest, replying, said it might have had that effect, but, at the same time, he had obtained signals which could be described as tremendously loud in the telephone, and without change of deflection, so he had no reason to suppose that as these signals got weaker in the telephone they would become uni-directional, or, if so, there was no reason to suppose they should when they are weak give an effect entirely lacking when they are strong.

Mr. Vreeland then asked if the author was inclined to the belief that the currents from the telephone were really alternating currents and did reverse? Dr. De Forest said he was.

Mr. Vreeland, continuing, said that was an interesting point. He did not think these analogies strictly scientific parallels. He did not know just how far one would push them into a refined analysis of the question, but they were certainly suggestive, and he thought they tended to crystallize our ideas as to the relation between the ionic phenomena in gases and those in electrolytes.

In closing the discussion, Dr. De Forest said that Dr. Pupin's opening remarks might serve as an argument why the study of Greek and Latin should be thoroughly introduced into our engineering schools. His knowledge of Greek was almost nil; he knew, however, that aud was of Latin and ion of Greek derivation, but they are both expressive. Where we use a term one hundred times a day, it is necessary to have something brief; we could not expect the wireless telegraph operators to use a long technical description of the apparatus in speaking of it.

As to the question Mr. Taylor brought up, as to why the milliammeter or sensitive direct-current instrument would not show any deflection at the time the telephone responded, he thought Mr. Taylor did not quite grasp the conditions. The sound we hear in the telephone, of course, represents the spark frequency. It is the frequency which affects the ear. These frequencies, if they are all in one direction, are sufficiently close together and are of sufficient intensity to produce an effect on the sensitive direct-current instruments. The only reason why they do not show an effect, perhaps, must be that they are alternately in one direction or the other. With an oscillograph we would find out just what the curve was. He hoped some day to find out their shape. They are undoubtedly alternating, rather than polarized.

He hoped to have the privilege of showing the audion in operation to the members of the Institute, and letting them hear the signals. He would like Dr. Pupin especially to hear them. Their intensity is at times so great that he must admit that they are caused by an electromagnetic current flowing through the telephone, and not electrostatic effects in the telephone between the core and the diaphragm, although the latter undoubtedly exist, and, under certain conditions, may predominate, but in the intense signals of which he spoke the quality of the tone is exactly the same as we get when we know we are alternating the current through the telephone.

As Mr. Vreeland pointed out, there are a number of analogies between the audion and the polariphone. They both employ ions or corpuscles, as the case may be, and the forms of the saturation curves, current and voltage curves, etc., are similar in both cases. He hoped the analogies would not be sufficiently close that the audion might be discussed by lawyers in patent cases.

Early Methods of Telegraphy

In view of the recent rapid advancements in the art of communicating over long distances, a description of some of the early methods, given by G. Lodian in the May, 1895, issue of "Cassier's Magazine, will be of interest here.—The Editor.

PUTTING UP A MILITARY TELEGRAPH LINE

"CONDE est repris!" "Condé is retaken! Condé will be restored to the Republic! Surrender to take place this morning at 6!" Carnot, grandfather of the late French President, had mounted the tribune in the National Convention and read a dispatch containing the above words. It was the 13th fructidor, 112 years ago. That dispatch was the first telegraphic national message of which the old Moniteur gives any record, whence are taken the preceding particulars.

At that time, struggling republican France was at war with nearly the whole of Europe, whipping her foes right and left. Condé was a town besieged by the Republican troops and it had just been retaken by them when the historic message above recorded was read to the Convention at Paris. From that moment aerial telegraphy was a triumph for France, and it continued to grow over the land for half a century until 1844.

It was on the 22d of March, 1792, that a young man, named Claude Chappe, presented himself at the bar of the National Assembly at Paris. He carried with him a secret vocabulary composed of 9999 words, represented by numbers, and destined to be transmitted by a system of visual telegraphy, aided by a machine which would signal from station to station. The examination of the project was at once put into the hands of a corps of investigation, who decided on its adoption and the Convention voted the necessary means for conducting a series of trials. The delegate Romme, mounting the tribune, thus announced to the Convention the particulars of Chappe's invention:

"The Citizen Chappe offers an ingenious means of aerial telegraphy by displaying a few characters, simple as the straight lines of which they are composed, very distinct one from the other, of rapid movement, and visible at long distances. At this first part of his procedure he is aided by a stenograph used in diplomatic correspondence. The employees working the Chappe machine cannot betray the secret of the messages entrusted to them because they will be ignorant of the stenographic value of the signals. The news of the taking of Bruxelles by the French troops was transmitted from that city over the Chappe apparatus to Paris in twenty-five minutes. Your com-

OPTICAL TELEGRAPHY

A SEMAPHORE STATION ON A CRIMEAN BATTLEFIELD IN 1854 mittee recommend the adoption of the system of Citizen Chappe."

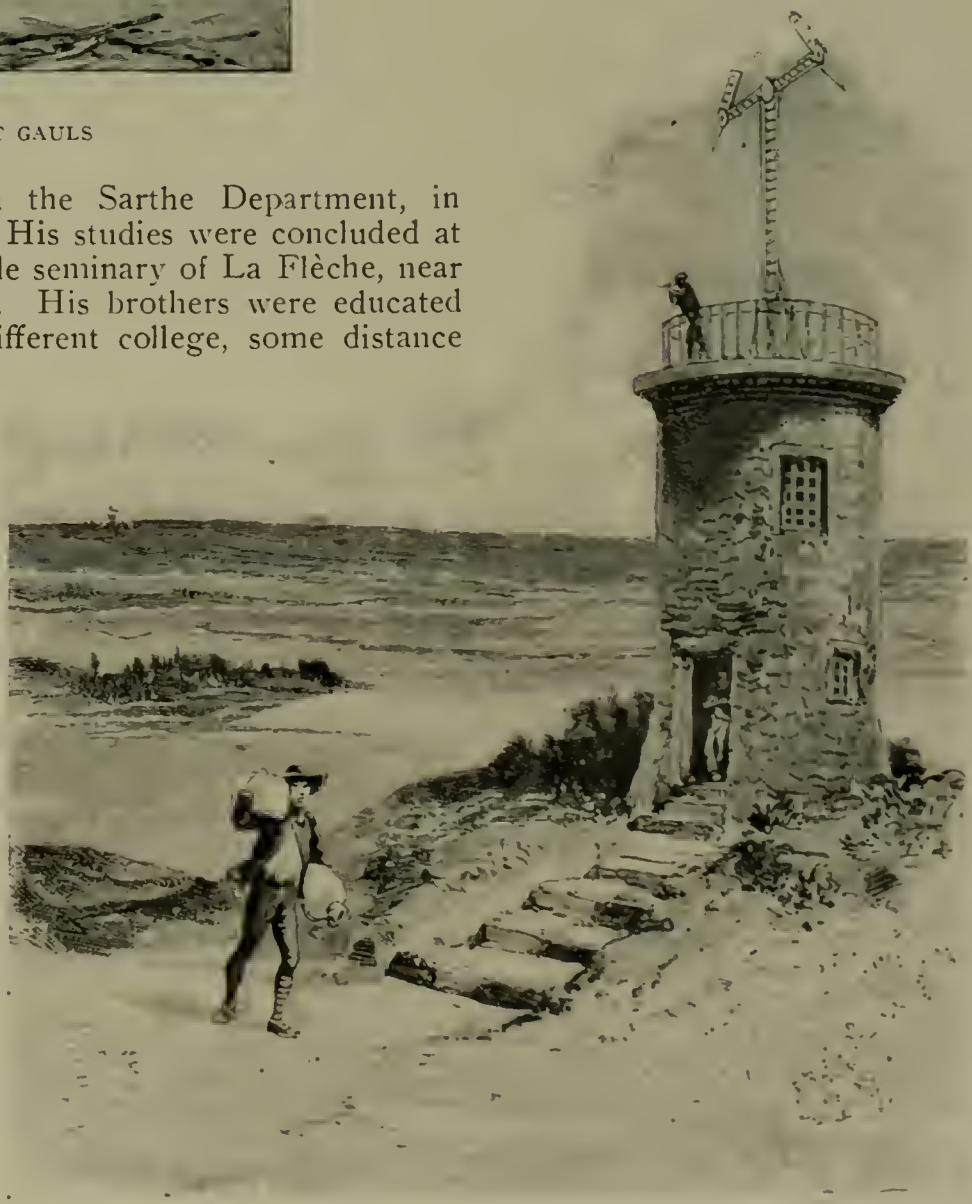
In the early spring of three years ago, during a holiday ramble of several hundred miles afoot right through France and over the lonely Pyrenees into Spain, the long walk occupying five weeks continuously, the writer saw numerous vestiges of what was once the greatest system of aerial telegraphy in existence. These were the remains of the solitary towers usually erected on the most prominent hillocks in the district, and which, up to 1844, formed the telegraphic system of France. In that year there were 535 stations, representing over 5000 kilometers of communication. In that year also the electric telegraph was successfully experimented with and the fate of aerial telegraphy was sealed. Wires were run up all over Northern France, but the lines were exclusively reserved for the use of the government.

SIGNALING BY THE ANCIENT GAULS

Not until the end of 1850 were private individuals allowed to send messages by telegraph, and then only (in the words of the law) "after vigorous constation (proof) of their identity." The tariff then was 3 francs, or 60 cents, for twenty words, and "the secrecy of the dispatches was declared inviolable." A few months later the first submarine cable was laid, between Calais and Dover, and the first regular message from England was that sent to Louis Bonaparte, then President of the Republic.

Claude Chappe was born at Brulon, in the Sarthe Department, in 1763. His studies were concluded at the little seminary of La Flèche, near Rouen. His brothers were educated at a different college, some distance from, but in view of, the institution where Claude was, and it is on record how, in order to communicate with them, he arranged a series of signals from his dormitory window. These being understood, were answered according to a code. That was evidently the foundation of Chappe's invention. Some say that this story is fictitious, but it is a decidedly pretty and natural one.

His study of the sciences was such that at the age of 20 years he "pleased an enemy"—if he had one to please. In other words, he wrote a book. These memoirs of his have been pronounced "very remarkable," although the student of physics who may consult them at certain great libraries will probably think otherwise. Chappe put up his first telegraphic machine at Belleville, the Bowery of Paris, but located it on high ground. There were "toughs" in those days, and it was these who destroyed the Chappe apparatus, so that the inventor had to seek police protection for future experiments. Chappe was the first man to receive the title engineer-telegraphist, and he received the pay of a lieutenant of engineers as in the service of the state. Delirious, through cancer of the ear, he committed suicide by



A LONELY POST IN THE HILLS, 1795

throwing himself down a well in 1805.

As with electrical telegraphy, so with aerial telegraphy, the early attempts were legion. A century before Chappe was born, a scientific attempt at long-distance telegraphy was made by the savant Amontons. The author Fontenelle has written of these experiments. He states that the apparatus was a clever contrivance, permitting the transmission of a message from Paris across the Alps to Rome in the then incredibly brief time of three hours, and this without anybody knowing the nature of the message between the Italian and French capitals.

The procedure consisted in placing at several consecutive spots men, who, having perceived through long-distance telescopes certain signals, made at one post, transmitted such signals to the next post, and so on from post to post, and these different signals were so many letters of an alphabet of secret ciphers. The key to these was known only to the parties interested at Paris and at the city a thousand miles away. The maximum range of the telescope constituted the distance between the different posts, the fewer of which, the better for rapid transmission. Some experiments were successfully made over a little stretch of country, but the vice-consumed functionaries of the time pronounced the Amontons project "impracticable," and the discouraged inventor abandoned his idea.

Cæsar, in his commentaries, relates how, during the invasion of Gaul, the inhabitants gave warning of his approach by burning fires at night. These signals were called "hauchées." In the daytime the old Gauls resorted to cries. Thus, a number of men, stationed at certain intervals apart over a long stretch of country, would shout their warnings from one to the other. This species of mouth-to-mouth telegraphy answered so well and the dispatches traveled so quickly that Cæsar states how, between the rising and setting of the sun, the natives could send a verbal message a distance of over 50 leagues. A league is commonly supposed to represent three miles (more or less (except the decimal league, which is 10 kilometers, equal to about 6¼ miles, so that the mouth telegraphy of the old Franks covered the respectable distance of about 150 miles a day. Bonfires and the "houppes" (from "huppa," to cry out) constituted the telegraphy of the ancients and moderns until 1792. In fact, up to the present day, in many parts of America and England, there is still preserved the long-distance French shout of "houppe-la," being more powerfully expressive than the English equivalent, "oh-there!"

The first Bonaparte extended the line of these stations to Milan, then to Mayence, in Germany. They went no farther. Soon the French armies began to retreat to the land from which they had come, and as they retired they fired their telegraph posts to prevent the enemy from using using them.

A not well-read writer has stated that Alexander's quickest means of sending messages was by fast horses, and that Napoleon, two milleniums later, was no better off. This informant, like millions to-day, was ignorant of aerial telegraphy's half century of existence as described in this article.

CHAPPE'S FIRST APPARATUS, 1792

The old telegraph stations of France are interesting relics of the past and, where they have been allowed to remain, form a feature of the landscape. They were of two kinds, the square towers and the round towers. They consisted of two stories, and the index signals, of wood or light iron, were mounted at the top of a pole on the roof. A ladder ran up this pole, so that the signals might be reached and moved by hand. The telegraphers were provided with telescopes and there was always somebody on watch on the roof to note signals made at the neighboring stations. The progress of a message at night was naturally slower than the day transmission. The words were fewer at night also, because small lanterns affixed to indexes could occupy only a certain number of positions without being extinguished.

A recent development in electrical devices for domestic use is an electric door bell, which in many respects is similar to the ordinary electric door bell as commonly used for years; but this new one eliminates the use of batteries, which from time to time need renewing, and unless the owner or occupant of the house is mechanically inclined the renewal of the batteries generally means something more than trifling expense. The first cost of the new door bell installation represents the only expense attached to it, as it is a permanent installation thereafter, and no repairs or renewals are required. The amount of electricity required to operate it is so infinitely small as to be negligible.

The Series Luminous Arc Rectifier System

By N. R. BIRGE

A Paper Read Recently Before the Ohio Electric Light Association

BEING the practical embodiment of the modern developments in lighting work, the new luminous arc rectifier system represents a great advance in the art of illumination. Energy, economy, the brilliancy of illumination, and the character of light distribution are marked advantages of this system. Two of the essential features are the luminous arc lamp with absolute cut-out on the line, and the mercury arc rectifier set in the station. This

FIG. 1.—EXTERIOR OF A SERIES LUMINOUS ARC LAMP

rectifier is supplied with alternating current and furnishes direct current to the lamps, which are designed to operate on direct-current circuits of 4 amperes, with 75 to 80 volts at the terminals.

As seen in Fig. 1, the main frame of the lamp consists of a single large tube, which acts as a chimney for carrying away fumes of the arc. At the top of the lamp are wind shields, which prevent a downward draught into the tube. Electrodes for these lamps differ entirely from the ordinary carbons used in arc lamps, the upper one consisting of a bar of hard-drawn copper supported by iron wings, while the lower electrode is made of a specially prepared composition contained in an iron tube ⅝ inch in diameter by 8 inches long.

Inside the globe and in close proximity to the arc is a horizontal reflector that serves to throw an ample volume of light below the lamp, without interfering with the main distribution of light in the horizontal direction. The closed base outer globe, the lower part of which is frosted, ensures an even distribution of the light directly beneath the lamp.

As can be seen in Fig. 2, the mechanism of the lamp is without floating parts, and when the lamp is out of circuit its electrodes are separated, with the lower electrode carrier retained by a stop which holds the tip of this electrode at a fixed distance from the upper one. When the current is thrown on, the pick-up by the starting magnet brings the lower electrode into contact with the upper one, thus allowing current to flow through the series magnet and thereby open the circuit of the starting magnet, so that the lower electrode falls and strikes an arc. At this point the lamp is burning with the lower electrode carrier resting on its stop and with the series magnet holding the cut-out contact open. As the lower electrode is consumed, the voltage across the arc rises and the shunt magnet lifts its armatures so that the cut-out contact is closed as soon as the arc voltage has reached a predetermined limit. Closing of this contact puts the starting magnet again in the circuit and thereby causes the lower electrode to be picked up and the arc started as before, with the correct length for proper operation.

Since the series magnet is of low resistance, it causes a drop of only a volt or so between the terminals of the lamp and arc when the lamp is in operation. Owing to the design, there are only two adjustments necessary, these being the adjustment of the shunt armature to feed the lamp at its proper arc voltage and the setting of the stop for the lower clutch to determine the proper length of arc. Since an absolute cut-out is installed with each series lamp, the switch that has been ordinarily used with lamps of this type has been omitted as being unnecessary.

In addition to its other advantages, this lamp has a high efficiency, readings made with a luminometer having shown that, consuming 310 watts at the terminals,

FIG. 2.—MECHANISM OF A SERIES LUMINOUS ARC LAMP

it gives the same intensity of illumination at a distance of 309 feet as the 480-watt, direct-current series enclosed arc lamp gives at a distance of 275 feet. Owing to its qualities of distribution and diffusion, this lamp is ideal for street lighting purposes. All the light comes from the arc, which is exceedingly long, so that the axis of maximum distribution is almost horizontal and there are no heavy shadows and contrasts. More than this, the maximum and minimum luminometer readings differ but slightly, for the electrodes offer practically no obstruction to the light and the distribution is not disturbed by the

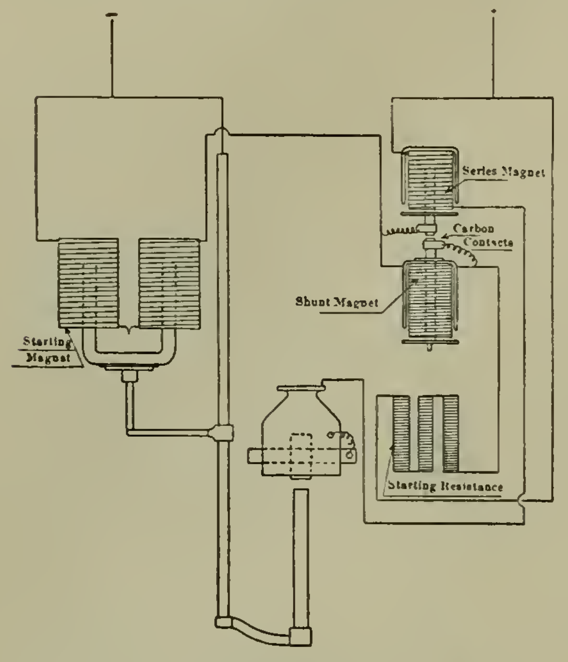


FIG. 3.—CONNECTIONS OF THE LAMP MECHANISM

wandering of the arc, as in the case of the open type of lamp.

Another feature which makes the lamp desirable for street illumination is the fact that the spectrum of the light produced is practically the same as that of sunlight and is as white as any artificial light in commercial service. Low maintenance cost is another one of the features of the luminous arc lamp. The upper electrode, being made of copper, has a life of about 4500 hours, and can be renewed at a practically negligible cost, while the lower electrode has a burning life of from 150 to 275 hours, so that one man can take care of and trim a much greater number of lamps than is possible with the open or enclosed carbon arc lamp.

The transformers used with the rectifier outfit have the same general appearance and characteristics as those used with the series alternating arc lighting system, the primary windings of the transformer being connected to an alternating-current supply of practically any voltage. Through small reactances, the secondaries are connected to the anodes or alternating-current terminals of the rectifier tube, and a tap at the middle of the secondary connects the transformer with one end of the direct-current circuit on which the lamp operates. These connections can be seen in Fig. 3.

To obtain the proper adjustment for current in the lighting circuit, small weights are attached to the rocker arms which support the movable coils of the transformer, and this apparatus is such that it will regulate from full load to slightly below one-half load with constant secondary current.

Being enclosed in a common case, the small reactive coils protect the secondary from inductive kicks or high frequency oscillations which may be caused by disturbances on the line circuit. Another reactive coil is inserted in the direct-current side of the rectifier circuit in series with the lamp and serves to reduce the pulsations of the rectified current.

This tube is the means by which the alternating constant current is changed to direct current for the series circuit. It consists of an exhausted glass vessel containing a carbon or positive terminal in each of two side arms, and also two mercury starting anodes, as well as the mercury cathode, or negative terminal, at the bottom of the tube. A movable wooden holder serves to support the rectifier tube on the panel. To put the tube in operation, it must be shaked slightly, so as to cause a flow of mercury between the mercury starting anode and the mercury cathode, thus bridging the circuit and permitting a flow of current from the low voltage exciting circuit connected to the starting electrodes. By breaking this bridge, a small arc is formed at the bottom of the tube between the starting anodes and the cathodes, and, with this arc in operation, the main arc can be established by closing the primary switch of the constant current transformer, thus throwing the secondary of the transformer in circuit with the operating anodes of the tube.

With the tube operating at 4 amperes, there is a drop equivalent to about 25 volts or a loss of 100 watts which is constant at all loads. Under normal operating conditions the average life of the tube on 25, 50 and 75-light circuits is 400 hours, and reports from commercial installations show that the maximum life is about 1200 hours. This system can readily be adapted to circuits of any frequency from 25 to 140 cycles, the standard sets being designed for 60 cycles. When operated at full load and rated primary voltage and frequency, the efficiency of the rectifier set varies from 85 to 90 per cent., depending on the capacity, and, under the same conditions, the power factor varies from 65 to 70 per cent.

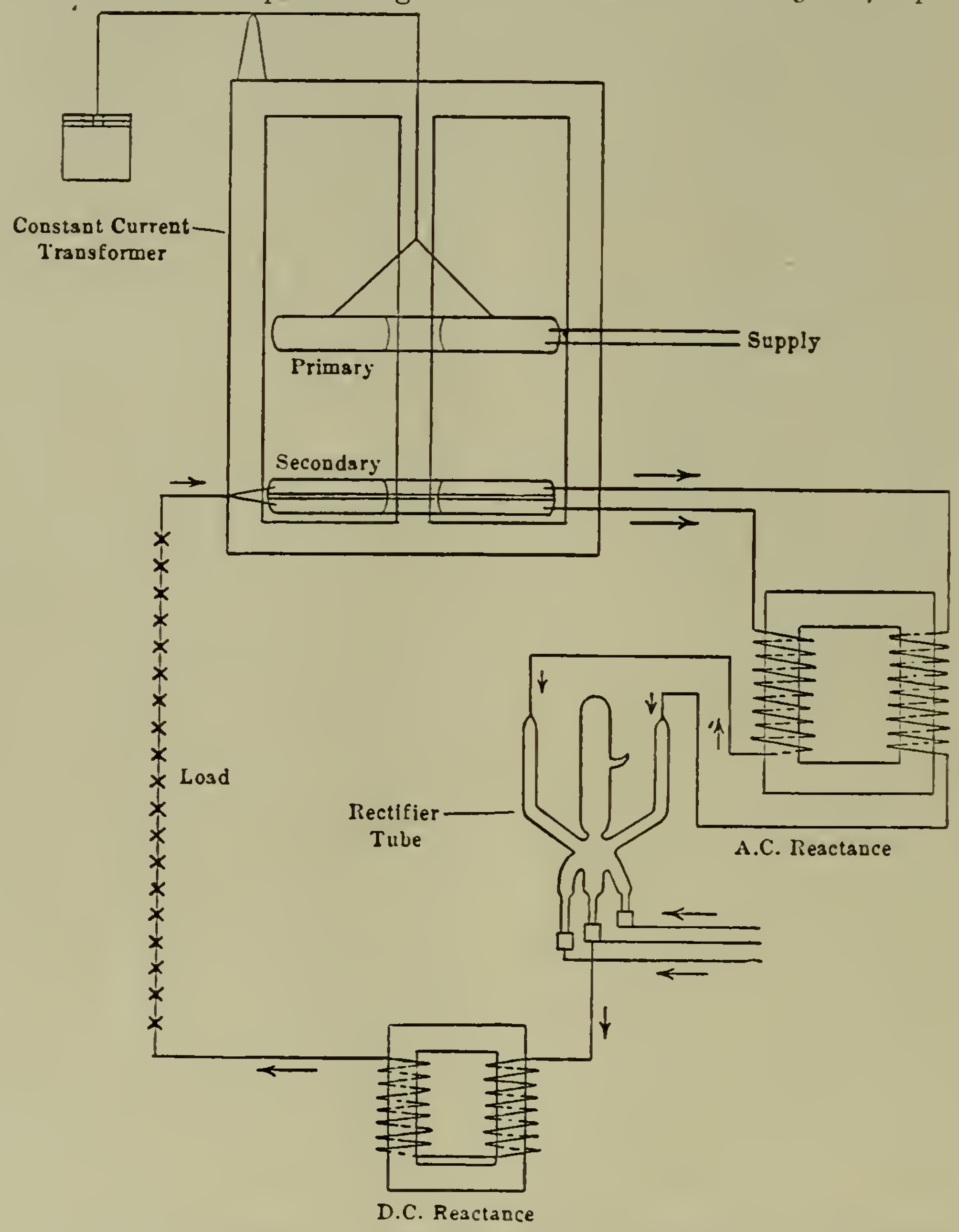


Fig. 4.—DIAGRAM SHOWING THE CONNECTIONS OF THE MERCURY-ARC RECTIFIER

From the World's Technical Press

A Method of Comparing the Efficiency of Electric Power Plants

IN a recent issue of "The Electrical Review," of London, C. J. Evans says that instead of comparing the efficiencies of electric power plants on the basis of cost of coal per kilowatt-hour, or pounds of coal per kilowatt-hour, a much more satisfactory way is to compare the British thermal units per kilowatt-hour.

For example, in the case of a station consuming 7 pounds of coal per kilowatt-hour, the coal having a calorific value of 14,000 B. T. U. per pound, the B. T. U. per kilowatt-hour would be 98,000.

This can also be expressed as what may be called the "Thermal Efficiency" of the station, which may be written—

$$\frac{\text{British thermal units in electrical energy}}{\text{British thermal units in coal consumed}},$$

or more conveniently,

$$\frac{\text{British thermal units in a kilowatt-hour}}{\text{B. T. U. in coal consumed per kilowatt-hour}}$$

One kilowatt-hour being equivalent to 3414 British Thermal Units, in the above example the "thermal efficiency" $= \frac{3414}{98{,}000} = 3.48$ per cent.

Even this basis of comparison is not strictly just, since a station using a poorer coal will have to handle a greater weight for a given thermal effect than one using a better coal; in a small station the difference in weight will not generally involve an addition to the staff, but in a larger one the coal handling plant will require rather more power, though in either case the difference thus made will be only a very small proportion of the total cost; and it does not allow for different load factors and such considerations.

Notwithstanding these objections, however, either the ratio "British thermal units per kilowatt-hour" or the "thermal efficiency" provides a very equitable basis on which to compare the economy and efficiency of different stations, since neither depends on the cost of the coal, the cost of its transport, or on its quality,—these varying greatly with different stations,—but only on the actual quantity of heat dissipated.

This principle could also be applied to steamships for the same purpose.

The Storage of Coal

IN discussing the storage of coal, in a recent issue of "The Engineering Magazine," A. E. Dixon says that coal is best stored under cover, but either under cover or in the open—in fact, from the time it is first exposed in the breast at the mine—all coals, bituminous and semi-bituminous in particular, are losing in heating value, a constant chemical change being in progress by which gas is being liberated. In warm weather or in hot climates this deterioration is more rapid than at low temperatures. These gases are frequently several times the volume of the coal, being occluded or condensed within the solid substance, until by diffusion they escape and are lost in the air.

This subject has been investigated by Dr. Lyon Playfair, in England, and Dr. E. von Meyer, in Germany, and the following figures are extracted from a report by the latter,

Sample.	Percentage by Volume				Cubic Centimeters of Gas Given Off from 100 Grammes of Coal.
	CO_2	CH_4	O	N	
1	16.51	trace	5.65	77.84	24.4
2	0.34	85.80	trace	13.86	91.2
3	1.15	84.04	0.19	14.62	238.0
4	0.23	89.61	0.55	9.61	211.2

showing the quantity and composition of the occluded gases in freshly mined samples of coal submitted to him. The method adopted to determine the amount of the gases was to place 100 grammes of the coal in hot de-aerated water, which was then boiled as long as any gas continued to be given off, the gas being collected and then analyzed by Bunsen's method.

All the above were English bituminous coal, the first being a Newcastle coal and the others from different seams in the same colliery in Durham. The second and third samples, while from different mines, were from the same seam. The depth below the surface from which these coals were raised was as follows:—No. 1, 180 feet; No. 2, 445 feet; No. 3, 650 feet; No. 4, 890 feet.

It will be noted that CH_4, or marsh gas, formed an important portion of the volume of gases given off by the latter three samples. This gas has a high thermal value. The same losses affect anthracite coal, but only to a slight degree. Oxidation or slow burning of the coal also occurs, and it not only loses in weight, but in heating value. In one instance the decrease in weight observed in some stored coal was over 35 per cent. after a lapse of some years.

Another trouble with stored coal is its heating and igniting spontaneously. Any bituminous coal of a friable nature, and particularly those containing "brasses" or iron pyrites (FeS_2), are liable to this trouble; when the coal is stored in a damp condition the trouble is aggravated. The cause of such fires is obscure, but they probably arise from the absorption of oxygen by the carbonaceous matter of the coal, in the same manner as oily cotton waste ignites from the same cause. In many plants the bunker construction is well designed to contribute to the starting of such fires, the entire boiler room being covered and no outlets being provided alongside of the bunker to permit the hot air arising from the boilers to escape.

These fires start at or about the bottom of the pile and may burn undiscovered for a considerable time. The indications of such a fire are a sensible rise in the temperature of the stored coal, a sickly odour, and a choking or smothering sensation in drawing breath when on that portion of the pile. Water is almost useless in fighting a fire of this kind, as the heat partially cokes the surrounding coal, forming a roof which prevents water reaching the fire in sufficient quantity to do any good, or the water will be turned into steam before reaching the fire.

Sometimes it is possible to drive pipes, with pointed ends in which a number of holes have been drilled, through the coal to the seat of the fire, and by this means water or steam can be used with advantage; but to be absolutely sure it is necessary to move the coal and uncover the seat of the trouble. In bunkers this is a very necessary precaution, as the pasty coke formed by the fire will stick to the concrete or steel and furnish a dead spot as a nucleus for another fire.

There is considerable conflict of opinion in regard to the best method of preventing such fires, ventilation being recommended; should this method be adopted, the ventilation should be thorough, for sluggish ventilation will not reduce the temperature of the pile, but, on the contrary, may tend to increase the trouble greatly. Fires of this kind are very common, but are usually discovered before they have made much progress. In large exposed piles there is less chance of their being caught at an early stage, and only a few years ago a fire of this kind burned for several months in a large pile, being finally discovered, because on this portion of the pile the snow melted as fast as it fell, while the remainder was deeply covered. This fire was a costly one, as several thousand tons of coal were consumed and considerable expense was incurred in extinguishing it.

Electrolytic Disinfectants

COMMENTING on the electrolytic disinfectant plant installed at Poplar, the London "Lancet" says:—"There can be little doubt that it is of the utmost importance that the electrolyzed saline fluid should be permanent as regards its strength, as represented in terms of available chlorine. Many improvements in a practical direction have been made, so that not only is an active antiseptic fluid turned out continuously and needing little attention, but one which keeps at a standard strength and is permanent.

"The solution used contains magnesium chloride and sodium chloride. Magnesium chloride used alone does not give satisfactory results, while it more readily furnishes active chlorine compounds than the sodium salt. The solution is made faintly alkaline with caustic soda so as to prevent the formation and escape of free chlorine in the cells.

"The electric current is governed automatically in order to give constant results and to avoid overheating. The stability of the newly electrolyzed fluid is secured by the addition of a proper quantity of caustic soda. At the Poplar installation a paddle with rubber flaps is rotated in the fluid at the moment when it leaves the electrolyzers, and it is intimately mixed with some caustic soda solution. The resulting solution shows no loss of strength.

"It is probable that this procedure results in the formation of a double hypochlorite of magnesium and sodium which, unlike the corresponding salt of magnesium, is quite stable. The process is extremely simple, and the plant requires only a minimum of attention, the output of the disinfecting fluid, constant in strength, being perfectly regular and continuous. The plant is capable of turning out an almost unlimited volume of efficient disinfectant by merely supplying a saline fluid and switching on the current. In time of epidemic such an installation should be invaluable."

Electric Lighting in Turkey

ACCORDING to "The Electrical Review," of London, the Sultan of Turkey has at last renounced his opposition to the introduction of the electric light in Constantinople. As a consequence, foreign promoters are seeking to obtain a concession, and their endeavors are attracting special interest locally.

Ten years ago the employment of electricity, except for telegraphic purposes, was in principle prohibited in Turkey, whereas to-day lighting stations and electric tramways have already been sanctioned for Beyrout, Damascus and Salonica. In Constantinople itself the electric light has so far only been introduced in some of the embassies and in the government buildings, but official circles have hitherto opposed the starting of a public electric supply, the establishment of a telephone service, and the transformation of the existing horse tramway to electric traction.

It was said years ago that the resistance was not insurmountable, and that it could be overcome by the payment of an equivalent backsheesh. Those in power at the palace seem to regard electricity as representing the principal card, which they refuse to play until they have received, it is reported, no less than $600,000. It is comprehensible that foreign promoters have hitherto held back in face of such a payment, especially as the electrical undertaking would be unremunerative at the beginning.

At present, however, two groups are endeavoring to secure the electricity concession. One is reported to be closely associated with the Rockefeller group of the United States, and the other is a German electrical company. The former is willing to pay $450,000 as backsheesh, while the German company has offered a few thousand dollars less than that sum.

Interchange of Traffic Between Electric and Steam Roads

THAT trolley cars and locomotives will be operated over the same tracks during the period of transition from the old to the new era seems to be settled, said C. A. Paul, in a paper read before the National Association of Railway Agents. In this way locomotives can gradually be relegated to the switching engine class, without that loss of investment which stockholders are so quick to think of when any change is suggested.

As a matter of fact, the steam roads with their heavy roadbeds would make excellent electric lines, and when the change is made will win back business on through lines which is now tending to go to the long-distance electric lines wherever they exist. When the steam road finds it expedient to adopt the new motive power they will find it will result in a great increase of traffic, as business will naturally gravitate to the roads having increased facilities for handling it.

The steam roads will be in a position to operate more frequent passenger and freight units, without a proportionate increase in operating expenses. These units can be of a size sufficient to take care of the traffic, varying large or small, according to the demand, operating passenger and express business on the multiple-unit system by which each car furnishes its own power from the line with its own motors, and is controlled in common with the other cars by the motorman. The heavy freight business would be handled by heavy electric locomotives.

When such a point of development is reached, the interurban roads and long-distance lines will be practically one system as far as motive power is concerned, and working arrangements between local and trunk lines with these increased facilities would be a logical result of the change. Cars operated on the trunk lines could be shunted to the local tracks for distribution, and vice versa. The two classes of roads will then settle naturally into their economic places and adjust themselves the one to the other, according to the class of traffic they are qualified to handle.

It is a peculiar fact that the latest developments in electric traction are such as would make possible such a condition of affairs; as the new single-phase motors are, in fact, only direct-current motors more highly developed, and while built to run on high-tension, single-phase current such as would be used on the main line, they can be adapted to operate on local 500-volt systems.

A car could run over the local lines of a community on 500-volt current, be transferred to the trunk line, make one unit in a through train, controlled by the multiple-unit system, furnish its own share of the power on the trunk line, and at the end of its run distribute its load over the local tracks of the city lines. Such an arrangement is one of the possibilities of the future, and would conform to the modern idea of centralization of power at a few economical points.

Electric Traction in the Simplon Tunnel

SINCE August 1, says "The Electrician," of London, the Brown-Boveri electric locomotives have drawn fifteen trains daily through the Simplon tunnel. The only steam-operated trains are the through trains *de luxe* (which run three times a week), and, in addition to these, one other engine passes daily through the tunnel from the locomotive sheds at Brigue for service between Iselle and Domo Dossola.

As was only to be expected, some technical difficulties were met with at first. Considerable deposits of soot had accumulated on the insulators of the overhead conductors, and these had to be very thoroughly cleaned during the intervals between working. Further, owing to the unusually damp condition of the atmosphere in which the motors have to work, it has been found advisable to completely enclose them and to depend entirely on internal ventilation, no air whatever being allowed to enter from the outside.

The electric locomotives have now been running regularly since August 1, and the whole system is working most satisfactory. In addition to the 1000-horse-power locomotives already supplied, Brown, Boveri & Co. have two similar locomotives in hand for the further requirements of this service.

The Treatment of Transformer Oil

THE successful operation of the higher voltage transformers, says S. M. Kintner, in "The Electric Journal," depends very largely on the condition of their insulation. As all transformers of this class are oil insulated and rely to a considerable extent on the oil for their insulation, it is of the utmost importance that the oil should be in prime condition.

It is generally known that the presence of water in oil is detrimental to its insulating qualities, yet it is hardly appreciated how slight an amount of water or moisture is required to very materially reduce the dielectric strength of the oil. According to C. E. Skinner, 0.04 of 1 per cent. moisture, or 4 parts in 10,000, is sufficient to reduce the dielectric strength one-half. The experience of the writer indicates that oil is even more sensitive to change than that. In a number of instances careful chemical analysis failed to show the presence of moisture, but an electrical test indicated its presence, the fact of its presence being established by re-testing the oil after the removal of the moisture.

The question that frequently confronts the operating engineer is how to remove the moisture from the transformer oil. If very much water is present, it will settle to the bottom of a sample drawn from the lowest point of the transformer. Another test more sensitive is to thrust a red-hot nail or rod into a sample of oil under test. If the oil "crackles," water is present.

In the electrical test of dielectric strength, average dry oil should not be weaker than 30,000 volts as the mean of ten tests for a 0.15-inch gap between ½-inch spheres. The oil should not break below 25,000 volts in any of the ten tests. Several ways of effecting the separation of oil and water are as follows:—Mechanical separation, capillarity, electro-static force, heating, vacuum and heating, and dehydrating.

When the oil contains considerable water or moisture, its greater density will cause a separation between the two materials, the water settling to the bottom. After this separation, the excess water can be readily drawn off. The same separation can be effected by passing the material through a centrifugal machine. The water in this instance will settle to the outside and can be drawn off. As the amount of drying that can be effected in this way is not sufficient for the higher voltage work, this separation needs to be followed by some other more complete method of drying.

The property of certain materials by which they allow water to pass through readily, but interfere with the passage of oil, has been made use of in the form of a separator. This is in the form of a disc, and is placed so that all water and oil passing to the treating outfit passes over the disc. The disc allows the separation of the excess water, and consequently relieves the treating outfit of a certain amount of work. The oil needs further treatment, however, before it is sufficiently dry for good electrical service.

One of the most common ways of using heat to remove moisture from oil is to immerse grid resistances which are heated electrically. The operation requires from ten days to two weeks of heating, which is very detrimental to the oil. This method should, therefore, be used only in those cases where other drying apparatus is not available. Another method of drying by heating is in blowing hot dry air through the oil, but this is also detrimental to the oil.

It has been found possible to dry oil by the use of a vacuum tank, heat being applied to the oil at the same time. The use of a vacuum lowers the boiling point of the water, and consequently makes it possible to eliminate the moisture without reaching a temperature that is detrimental to the oil. This method, where available, should prove satisfactory, and it is possible to secure an oil that is perfectly dry by this treatment. As a rule, it will require considerable time to thoroughly remove the moisture, and for this reason the method is not as convenient as the method of dehydrating.

Moisture can be removed from oil very rapidly and very cheaply by the employment of suitable agents for absorbing the moisture. The engineers of the Westinghouse Electric & Manufacturing Company have developed a treating outfit which employs this principle, in conjunction with the method of using a separator already described.

This outfit circulates the oil to be dried through a treating tank in which is placed a dehydrating material. The oil, after passing through this dehydrating chamber, is filtered, and thus all foreign materials that are in the oil, as well as any of the dehydrating material that may have followed through, are removed. It has been found possible with an outfit of this kind to dry a thousand gallons of oil in a day, and to have this oil as dry as required for the highest voltage service.

Lime is the material employed in the dehydrating tank. This material has been selected after testing a number of dehydrating agents, as it is usually available and introduces no possibility of injuring any part of the transformer if any of it gets through the filter with the oil. It has the additional advantage of tending to neutralize any acids existing in the oil.

A number of other satisfactory dehydrating agents have been used, and in some instances where special precautions are observed it may be found more advantageous to employ some of these than the lime. Dry sand has generally been used for the filtering material, although in some instances it has been found advantageous to mix in certain proportions of bone-black and Fuller's earth, these last two having the property of tending to clear the colour of the oil. As a rule, dry sand will be found sufficient.

Electric Train Lighting in India

SUPPLEMENTARY to the article in the October number of The Electrical Age, on electric train-lighting systems, some particulars on this subject, taken from "Indian Engineering," will be of interest.

On the Kalka-Simla Railway, which passes through a series of tunnels from end to end, all the coaching vehicles are provided with an apparatus that switches on the light without the passenger's intervention. The Rajputana-Malwa State Railway has 340 of its coaching vehicles, which are used on the Delhi-Ahmedabad through mail and passenger service trains, fitted with the electric light.

The South Indian Railway, which has 99 coaching vehicles provided with electric lights, is still dealing with the matter only experimentally; while the Madras Railway have decided to give the system a practical trial with a view to its adoption in mail and fast passenger trains. A few other railways propose introducing this improvement, among them being the Indian Midland and Great Indian Peninsula Railways, which have 29 coaches fitted with the electric light; the Jodhpur-Bikaner Native State line with 80 vehicles, and the Burma Railways with 20 vehicles.

The locomotive and carriage superintendent of the Burma Railways reports upon a six months' trial of the Vicarino-Crawford system. "During this time," he says, "the equipment has given no trouble and shown no faults. The only parts we have had to renew, due to fair wear and tear, were a pair of carbon brushes, which were renewed after 16,829 miles in traffic service. The vehicle has up to date run 37,803 miles. The light has been brilliant and perfectly steady, there being no perceptible difference between the illumination when standing and when running"

The Future Development of the Steam Turbine

WHEN we consider the results as regards steam consumption which have been obtained up to date by the various types of turbine, says A. H. Gibson, in "Cassier's Magazine," it would appear that the reaction class is slightly more economical. It must be remembered, however, that considerably more time and money have been spent in bringing this class to its present state of perfection than in the case of the more recently developed impulse class, and that for very large powers where the impulse class, as represented more particularly by the Curtis and Riedler-Stumpf turbines, might be expected to give good results, the reaction class has so far almost had a monopoly.

In view of the very many and very real advantages common to the impulse class of turbine, it would appear that future development is to be looked for along these lines, and that the reaction class of machine is labouring under disadvantages natural to its method of using steam, which will in the future handicap it very considerably in the race for supremacy. The chief drawback at present to the impulse class arises from the fact that a current of high-velocity steam requires very delicate handling if its flow is not to become unsteady and if eddy motion is to be avoided. This involves extreme care in devising the nozzles and in designing the shape and varying areas of the steam passages; it is, therefore, in the improvement of these details that future development may be looked for.

If the gas turbine becomes a commercial success, it will undoubtedly be by development along these lines. The moving fluid in this case, because of its comparatively high specific gravity, lends itself more readily than does steam to the impulse class of turbine.

Again, owing to the very high temperature of the formation of the working fluid, the impulse method reduces the temperature of the fluid before its admission to the turbine proper, by expansion in the diverging nozzles, and is thus the only practicable and convenient means of overcoming the difficulties caused by such high temperatures.

Since the gas on entering the turbine casing will be at a comparatively low temperature, the necessity for a water jacket, which generally carries away about 40 per cent. of the total heat generated in a gas-engine cylinder, is obviated, and a direct saving over the gas engine of this amount of heat is obtained in addition to the advantages of this type of prime mover from a purely mechanical point of view.

It would appear then that we are at present well in view of the ideal prime mover, economical in working and in first cost, simple in construction and of unimpaired efficiency after long periods of operation. When we add to this its adaptability for most of the purposes for which a prime mover is required, the gas turbine would appear to be an ideal worthy of the aims and aspirations of every mechanical engineer.

Earnings of Central Stations in German Cities

SOME interesting figures showing the financial condition of central stations in German cities of from 1000 to 5000 inhabitants, are given in a recent issue of the "Elektrotechnische Zeitschrift." New figures were obtained from sixty-four cities, showing a variation in gross earnings of from 19.7 per cent. to minus 0.6 per cent., the average being 8.4 per cent.

Plants with a gross earning of 8 per cent. or more are termed "good," and those earning less are "bad." The latter show a greater first cost and low receipts. In the bad plants also the ratio of wages and salaries to receipts is about 20 per cent., and in good plants it is 15.9 per cent. The figures indicate that even in cities of 1000 inhabitants it is possible to operate an electric plant to secure a good return on the investment, and that the presence of a gas plant should not interfere with the electric plant doing a good business.

The point emphasized, however, is that it is very essential in small plants to keep wages and salaries as low as possible. If these amount to 20 per cent. of the receipts, profitable operation will be very difficult. In some of the stations considered they were 40 per cent. It is desirable to keep below 20 per cent., and some of the unprofitable stations were placed on a profitable footing by having the labour cost reduced to this point.

One disadvantage under which small stations labour is that they are not as favourably located as are larger stations. The limited use of automatic machinery possible and the higher cost of fuel are also difficulties. With large stations, moreover, the introduction of high-efficiency lighting units, while making for cheaper lighting, increases the sales of current in large cities. In small cities, however, the lighting load is small, and it is a question whether or not the introduction of high-efficiency units would have the same result as in a large plant. It is believed that the increased consumption of current can be obtained only in cities where a gas company is doing business, as the cheaper electric light will induce customers to use electricity for lighting instead of gas.

The Principle of Sound Engineering for Inventors

THE broad general principle of what may be called the inventive branch of engineering, says Thorburn Reid, in "Cassier's Magazine," is that invention is an art that requires in those who would practice it successfully certain rare and valuable qualities of mind which are only occasionally combined with sound commercial engineering or business judgment, and that, therefore, the inventor's activities should be confined to invention only, while the work of developing the inventions and placing them on the market should be delegated to commercial engineers and business men who possess the practical judgment that the inventor nearly always lacks.

It is not forgotten that commercial engineers in the regular course of their work sometimes devise new machines or methods that are patentable and valuable, but such cases are sporadic and more or less accidental, for it is almost invariably the case that the work of the commercial engineer loses in value and efficiency by just so much as he directs his attention and efforts towards invention. It is, therefore, the part of wisdom for him to confine his attention to the solution of the problems in hand by sound engineering methods and consider inventions as a mere accidental by-product.

An Interesting Hydro-Electric Plant

A HYDRO - ELECTRIC plant possessing some very interesting features is described by C. T. Rice in "The Engineering and Mining Journal." The plant is that of the Eustis copper mine, in the province of Quebec, Canada.

The two alternators supplying current are run in parallel, and are mounted on the same shaft and driven by turbine water-wheels. The water from the dam is carried by a flume to three pairs of 18-inch horizontal turbines mounted on one long shaft, on each end of which is rigidly coupled a revolving-field alternator, one 150 KW. in capacity and the other 200 KW. These alternators generate a three-phase, 25-cycle, 2200-volt current.

The effective water head on the turbines is 38 feet. Each pair of turbines is fitted with a separate gate-valve. The gate-valve of the centre pair is operated by a hand-wheel, but the other two are operated by Woodward compensating governors.

In starting up, the hand gate-valve is opened, and when the capacity of this pair of wheels is reached the automatic governors are thrown into gear. In this way either one, two, or three pairs of turbines are run according to the amount of power required. This effects a great saving of water, for each wheel is run more nearly at its full capacity.

The fields of both alternators are excited by a 13-KW. generator, which is driven by a belt from a pulley on the turbine shaft. Both fields are in parallel. A Terrill automatic regulator, mounted on the switchboard, and inserted in the fields of the alternators, keeps the current properly distributed between the two alternators, and thus the primary voltage is kept constant. A hand rheostat is also in each field circuit, so that the fields can be regulated by hand in case the Terrill regulator gets out of order. A reserve exciter, run by a separate water-wheel, is used in case of accident to the other.

When only one alternator is generating a current and it is desired to use both, the field of the second alternator is thrown into circuit, and when the voltage is equal to that generated by the other machine the second machine is thrown in step. This type of design obviates the difficulty often attendant upon running alternators in parallel, for there is no trouble getting the two alternators in step.

The only difficulty in such a plant is connecting the two alternators in phase. This was done as follows:—One alternator was coupled to the turbine shaft. Then the other was lined up with the turbine shaft and the couplings of each brought so near together that they almost touched. The second alternator was run as a synchronons motor, and when synchronism was established the faces of the couplings, which had been previously blackened by camphor smoke, were marked with a scratch awl drawn rapidly across the two coupling surfaces. Holes were then bored and the alternator rigidly fastened to the turbine shaft. The alternators were then always in phase.

News of the Month

The Co-operative Electrical Development Association

A FEW weeks ago Arthur Williams, president of the National Electric Light Association, appointed a committee of five central station managers to co-operate in the developing and execution of the plans of the Co-operative Electrical Development Association. This committee, which consisted of three members last year, has been enlarged this year to a committee of five, consisting of the following gentlemen:—

W. W. Freeman, of the Brooklyn Edison Company, chairman; John W. Gilchrist, of the Chicago Edison Company; R. S. Hale, of the Boston Edison Company; J. K. Montague, of the Buffalo & Niagara Falls Electric Light & Power Company, and F. M. Tait, of the Dayton Lighting Company.

Paul Spencer, who was chairman until recently rendered excellent service in the development of the plans last year, but special attention required on another committee necessitated his withdrawal.

Mr. Freeman called a meeting of the committee in Brooklyn on October 30, and the entire day was given over to a careful and detailed consideration of the proposed constitution and by-laws, as well as the detailed commercial plans for 1907 submitted by J. Robert Crouse. President Williams was present at the meeting for a good part of the day.

This conference, which will be followed rapidly by similar conferences with the co-operating committees of the manufacturers, jobbers, contractors and representatives of the technical press and advertising agencies, is all preliminary to a meeting of the joint committee of all branches of the trade, to be held in New York within a few weeks, at which it is expected to formally complete and finally agree upon a scheme of organization and the commercial plans for work in 1907.

After a very busy day, Chairman Freeman and his associates, F. F. Wells, Joseph F. Becker, Jr., P. R. Atkinson and M. S. Seelman, gave a dinner for the confréres at Delmonico's, followed by a theatre party. The day's activities concluded very pleasantly with a luncheon and smoker given by President Williams.

It was the unanimous expression that the day had been crowded as full of "co-operation," both business and social, as was possible, and this meeting doubtless marks a long step in the progress of this co-operative campaign, which is coming to be recognized by all branches of the trade as having very great commercial possibilities.

Meeting of the Schnectady Branch of American Institute of Electrical Engineers

THE third meeting of the season of the Schenectady Branch, American Institute of Electrical Engineers, was held on Saturday evening, Oct. 20. Dr. Rossiter W. Raymond was the speaker of the evening, and made an address on "Professional Ethics," a subject of great interest at present to all electrical engineers on account of President Wheeler's address at the Milwaukee convention of the Institute and the present activity on the part of the Institute's special committee recently appointed to formulate a code applicable to the electrical profession.

Dr. Raymond was greeted by an enthusiastic audience of about seven hundred, and the value of his remarks amply justified the large attendance.

As president of the American Institute of Mining Engineers for several years, as the efficient secretary of that body for some twenty years, and as editor for years of "The Engineering and Mining Journal," which he founded, Dr. Raymond is particularly well equipped to speak with authority on the subject he chose. He addressed his remarks to the young engineers and students, speaking for loyalty to one's employer and to one's self, with a fund of anecdotes and wit that seemed inexhaustible and kept the room in laughter between the serious portions of his talk. He gave much good advice and summed up with the following general rule of engineering ethics:

"Do not do what you cannot tell, or if there be a good reason for not telling the details, do not do what you cannot tell without shame."

The speakers were introduced by Chairman Rushmore, and among the others were Dr. Geo. R. Lunn of the First Reformed Church, Dr. W. R. Whitney of the research laboratory of the General Electric Company, and Prof. Hoffman, of Union University.

The branch meetings are held in the auditorium of the Schenectady High School, and the officers of the Branch are greatly gratified by the continual increase in the size of the audience. Although the admission was by ticket only at this meeting, the attendance was the largest in the history of the branch.

An interesting feature of the meeting was the large number of men who came prepared to join the branch. The membership committee has succeeded in building up a branch membership which already is more than three times the number of regular members and associates of the national body residing in Schenectady. At the same time, however, the local membership of the parent organization has been greatly increased on account of the activity of Institute work at Schenectady.

Weekly meetings are being held through the winter. On Friday, October 5, the branch was addressed by T. Commerford Martin on "Technical Journalism," and on October 12 by E. G. Acheson on "Inventions and Discoveries." The list of men for future meetings is sufficient to carry the branch well into next year with the same class of lectures.

Annual Meeting of the Kansas Gas, Water & Electric Association

THE Kansas Gas, Water & Electric Association held its annual meeting in Lawrence, Kan., on October 16 and 17, fifty-six members of the association being present. The following officers were elected for the ensuing year:—President, E. S. Springer, Leavenworth; first vice-president, C. L. Brown, Abilene; second vice-president, F. L. Williamson, Clay Centre; third vice-president, H. F. Jackman, Minneapolis, Kan.; secretary and treasurer, James D. Nicholson, Newton, Kan.; executive committee, John C. Nicholson, Newton; M. A. Patten, Topeka; F. D. Aley, Wichita.

After the address by President W. E. Sweezy, the following papers were read and discussed:—"Kansas Water Survey," Prof. F. O. Marvin; "A Problem of the Country Light Plant," H. V. Forest; "Composition of Natural Gas," Prof. E. H. S. Bailey; "Developing a Day Load for Small Central Stations," C. L. Brown; "Relation of Kansas University to the Electric Industry of Kansas," Prof. R. M. Freeman; "The Future, What Shall It Be?" F. L. Williamson; "Profitable Co-operation," J. Robert Crouse.

The place of next meeting will be at Topeka, and the date, October 16, 1907.

Several new members, central station managers, were added to the list of members. The president and the assistant secretary expect to do some energetic work in the "Wrinkle Department" and have a good question box at the next meeting.

The meeting was considered the best of the Kansas Association, and the officers look forward to a bright future for another year.

Electric Lighting in Uruguay

UNDER recent date from Montevideo, Uruguay, United States Consul John W. O'Hara reports that a law has been enacted by the Congress of Uruguay providing for the expenditure of $1,200,000 Uruguayan gold, equal to $1,240,800 American gold, for the improvement and extension of the electric lighting system of the city of Montevideo and suburban towns. For the purpose of securing the necessary funds to pay for these improvements, it is provided that the city shall issue debenture bonds bearing annual interest at the rate of 5 per cent. per annum, and 4 per cent. annual amortization.

American manufacturers interested in the manufacture of electric lighting machinery and apparatus may obtain full information by addressing J. A. Capurro, Ministro de Fomento, Montevideo. Although the plans have not yet been published, it is evidently the purpose not only to renew and extend the present public system, but also to add a general commercial system. Agents of the government have been sent to Europe to investigate electrical plants and machinery.

The Chicago Electrical Trades Exhibition

CHICAGO'S second annual electrical show, which is to be held in the Coliseum, January 14 to 26, promises to be of unusual interest. Managing Director Homer E. Niesz is authority for the statement that 85 per cent. of the floor space in the main building of the Coliseum is already sold. It is more than probable that before January 1 there will not be an available space to be had. This means that the Coliseum Annex will be used for exhibitors.

Mr. Niesz is just now giving much of his attention to the matter of reduced railway rates from points in the Middle West, and for this purpose it is probable that the contemplated organization of the Allied Electrical Trades Association will be revived. It is proposed to bring the electrical men of all trades together in this association, holding meetings during the exposition to discuss topics of general interest. Members of the proposed association will not only be eligible for the reduced railway rates, but will also be provided with a ticket to the exposition, good throughout the dates of the convention, and will also be given the privileges of the Electrical Trades Club, specially furnished rooms for which are to be provided at the Coliseum.

Telephone manufacturers are taking an unusually keen interest in the coming show, owing to the keen rivalry between the independent and the Bell interests. All telephone exhibitors of last year have taken double the space for the coming show, notably the Chicago Telephone Company, American Telephone & Telegraph Company, the Automatic Electric Company, Swedish-American Telephone Company, Stromberg-Carlson Company,, Kellogg Switchboard & Supply Company, Frank B. Cook, and other firms which manufacture directly or indirectly for the telephone interests.

Mr. Niesz and Vice-President E. B. Overshiner recently visited New York to confer with Dr. Thaddeus Cahill, the inventor of the telharmonium, with the view of having one of these installed and demonstrated at the 1907 show.

Opening of the United Engineering Building in New York

AT the October meeting of the American Institute of Electrical Engineers, Secretary Ralph W. Pope said that the new building in New York to be occupied jointly by the several engineering societies would be practically ready for occupancy on December 1, and would be in operation by December 15, to be occupied by the officers and staff of the three societies. There will be no meetings held there, however, and no opening of an official character, until April next, as it is the intention to make the opening rather an important event in the engineering history of the country, with invited guests from foreign parts, and the arrangements for a function of this character will take some time.

It is also the purpose that the building shall be occupied, fully completed, and every department of the same in full and actual operation, before what may be termed the official housewarming takes place in the spring. Mr. Pope said that at about the time first mentioned, December 1, he presumed anyone would be permitted at least to look at the outside of the building, but it is the intention to refrain from anything in the way of an opening that may be publicly reported, in order that there may be no dampening effect on the grand opening which is to take place in the spring. He had personally within a month been through the building with some members of the Institute, and they were all impressed with its very suitable character, and felt satisfied that everyone would be pleased with it. From what he saw at that time, the tenth floor, which is to be occupied by the Institute, was practically completed, with the exception of the finishing of the woodwork. The only thing in the building which remained for final completion was the main auditorium and grand entrance hall on the ground floor.

Importing Niagara Power

IN order to deal more intelligently with the question of transmitting Niagara power from Canada to the United States, Secretary of War Taft some time ago appointed Captain C. W. Kutz, of the Army Engineer Corps, to investigate the subject and submit a report. Concerning the Ontario Power Company, the Electrical Development Company and the Canadian Niagara Power Company, the report says:—

"All three of these power developments were undertaken in good faith several years ago and long before the agitation in Congress which led to the passage of the present law, and there is no evidence that any of their subsequent transactions were made with the object of securing rights which they have not always intended to claim.

"The total capacity of the generating machinery installed and ordered for the three plants is 171,000 horsepower. The probable demand in the near future from Canadian markets will not exceed 40,000 horse-power, leaving 131,000 horse-power for sale in the United States. The granting of permits for this amount would permit the utilization to its full capacity of all machinery now installed or ordered, but would not permit any further development and would not afford a reasonable return on the moneys now invested unless the price to the consumers was measurably increased. In order that such relief as is now possible may be afforded, it is recommended that permits be granted for 157,500 horse-power, the maximum amount under the first limitation, less 2500 horse-power reserved for the International Railway Company.

"As to the question of granting transmission permits for amounts additional to the first 160,000 horse-power, it is believed to be the intent of the law to delay the issue of such permits until it is known what appreciable effect, if any, will be produced on the Falls by the diversion of the amount of water that will be used under the first limitation. If this interpretation of the law is correct, the granting of such permits will be a matter for the future, as it will be fully a year before the companies will be in a position to develop 160,000 horse-power in addition to the amounts sold in Canada."

The report also recommends that the Niagara, Lockport & Ontario Power Company be permitted to transmit 60,000 H. P. into the United States; the Niagara Falls Electrical Transmission Company, 37,500 H. P., and the Niagara Falls Power Company, 60,000 H. P.,—157,500 H. P. in all. The American members of the International Waterways Commission concur in this recommendation.

The report says, further, that if the three companies be limited to the output of generating machinery now actually installed or ordered, their investment in power plant per horse-power, exclusive of franchises, will range from $89 to $125. But if they are allowed to develop to the limit of their approved plans, these investments will be cut down to from $60 to $68 per horse-power developed.

The Regulation of Public Service Corporations

SPEAKING on the governmental regulation of public service corporations recently, John I. Beggs, newly elected president of the American Street & Interurban Railway Association and president of the Milwaukee Electric Railway & Light Company, advocated a State commission of three men uninfluenced by politics instead of a common council to place restrictions on public service corporations.

"I do not think," said Mr. Beggs, "that any of the large public service corporations are afraid of honest regulation. What we are most afraid of is that the present frenzied public opinion will bring about a condition of affairs in which the corporations will receive but little consideration. We are afraid of the regulation of the demagogues of a common council who have developed a hatred toward all corporations and have gone forth as the 'saviours of the dear people.'

"Securities of public service corporations are quoted at higher figures in the State of Massachusetts than in any other State in the Union. Why? For the simple reason that there we find sane and honest regulation. No road can enter there that would make competition ruinous. No additional capital can be agreed upon without a substantial reason for issuing the stock and stating to the commission the purposes to which the additional capital is to be devoted.

"Another example is the State of Missouri. Several years ago a yellow press in the city of St. Louis started an agitation in which they maintained that the assessed valuation of the street railway properties in that city should be increased to $50,000,000. The officials of the company argued that the valuation should not exceed $17,000,000. On the State Tax Commission at that time was Governor Folk, who has acquired a national reputation, and Attorney-General Hadley, who has made the Standard Oil people come to time. After conducting an investigation the assessed valuation of the properties was increased but a few hundred thousand dollars. This illustrates the benefit of sane regulation."

Hydro-Electric Power in Winnipeg, Canada

UNITED STATES CONSUL S. H. Shank, of Winnipeg, reports that the Winnipeg River has a series of falls from which it is possible to develop 300,000 or more horse-power. The Winnipeg Electric Railway Company has a power plant at Lac du Bonnet, where they have a head of about 40 feet and facilities for generating about 25,000 horse-power, which may be increased to 50,000 horse-power.

The city of Winnipeg has authorized the construction of a municipal power plant at Point du Bois, on the Winnipeg River, and preliminary surveys for this work have already been made. The distance of this place from Winnipeg is 72 miles. It will be necessary for the city to construct a 20-mile steam railroad for transporting machinery and materials. There is a head at this point of 46 feet, making about 60,000 horse-power available at low water, with the possible maximum of 100,000 horse-power.

At the present time it is proposed to construct a power plant with five 5000-horse-power machines, which, it is estimated, will deliver 18,000 horse-power in the city of Winnipeg. It is estimated that the cost of this in Winnipeg will be $17 per horse-power. It will take about three months for the engineer to complete plans and specifications before tenders will be asked for. All inquiries regarding the proposed work should be addressed to Cecil B. Smith, engineer of power construction, Winnipeg, Manitoba.

Fuel Briquettes

A PRELIMINARY report of the tests of fuel briquettes made by the United States Geological Survey says that the high cost of pitch, which is generally used as a binding material, is one of the barriers now existing in the development of the fuel briquetting industry. The most favourable outlook for the development of the industry in the United States is in connection with the use of briquettes in locomotives and in domestic furnaces and stoves. It can hardly be expected that, at anything approximating existing prices, briquettes can be manufactured for successful use in the ordinary power plant furnaces of this country.

In connection with the use of briquettes, the following advantages are claimed:—They burn with a higher efficiency and with less smoke than coal, because they allow a better circulation of air and the combustion is more complete and uniform. They are cleaner, and there is less waste in their use. They burn with more flame (owing to the added combustible binding material) and at higher temperatures. They occupy less space than does lump coal, the difference being from 5 to 20 per cent. They stand handling and exposure to the weather better than lump coal. In their storage, there is no risk of spontaneous combustion.

Turbine Water-Wheel Tests

A PAPER of unusual interest to engineers and users of water-power is a compilation of turbine water-wheel tests and power tables that has just been issued by the United States Geological Survey. The results of tests of McCormick, Hercules, Samson, Swain, and other modern wheels by the Holyoke Power Company serve as a basis for the bulk of the data, but other tests and manufacturers' tables have been utilized whenever available.

One object of the paper has been to furnish information required in measuring the flow of streams where the turbine is used as a water meter. The paper contains rating tables and the results of tests of different makes of turbines with register, pivot, or cylinder gates, so that the power developed at the mills and the quantity of water used can be determined from the size and type of the wheels.

As the water rights of mills can often be definitely ascertained only from the quantity of water used, and as some of the wheels are no longer built or catalogued, the records of tests of the older types will be of great value to engineers who may be required to determine questions of water rights. The paper contains also a clear presentation of the evolution of the different types of turbines, all available data relative to the efficiency of the wheels and the power developed, a description of the best methods of turbine setting and arrangement, and a discussion of the conditions that govern the economy in size and number of turbines used.

This paper is probably the only published compilation of such data. Many wheels have been tested, but, as a rule, such work has been done for private parties, and the results have not been available to the engineering public. Copies of the paper, which is designated as Water Supply Paper No. 180, may be obtained from the director of the United States Geological Survey at Washington, D. C.

War-Time Rules for Wireless Telegraph Operation

THE Institute of International Law, which recently concluded its deliberations at Ghent, Belgium, adopted the following rules for the operation of wireless telegraph systems in time of war:—

The regulations governing wireless telegraphy in time of peace are applicable in principle in time of war. Belligerents may prevent the transmission of Hertzian waves by a neutral state over the high seas within the sphere of their military operations.

All persons taken prisoners while receiving or transmitting wireless messages from belligerent territory or between different sections of a belligerent army are not to be considered spies, but are to be treated as prisoners of war, unless their operations were carried on under false pretences.

Carriers of dispatches received by wireless who make use of concealment or ruse in their work will be regarded as spies.

Neutral ships and balloons proved to have been used to furnish an adversary with information helpful in the conduct of hostilities may be removed from the zone of hostilities and the wireless apparatus on board seized and sequestrated.

A neutral state is not obliged to prevent the passage across its territory of Hertzian waves destined to a country at war. A neutral state has the right to close or take over the wireless telegraphy station of a belligerent operated in its territory. Every prohibition in the matter of wireless communication made by belligerents must at once be communicated to neutral governments.

Freight Transportation by Electric Motor-Wagons

FROM Birmingham, England, United States Consul Halstead writes that an experiment is being made in North Staffordshire with a 70-horse-power electric motor-wagon for heavy freight traffic that may have far-reaching results, especially in the United Kingdom, where distances between industrial centres and the seaports are comparatively short.

The present experiment in using a heavy motor-wagon, of a capacity of six tons with a trailer carrying four tons, to carry goods from Hanley to Liverpool, is especially interesting to Birmingham, whose manufacturers constantly complain of high freight rates, unfair and inequitable classifications, and the autocratic attitude of the railways that act in concert, even though there is no concentration of ownership. A Birmingham paper says that "if the scheme should prove successful, the promoters hope in time to run wagons also to Manchester and Birmingham and to tap the big railway companies at convenient points. As the scheme develops the promoters propose to establish depots and warehouse accommodation in the same way as railway companies, and they profess to have every hope of a successful issue to their enterprise."

If it be found that freight can be carried expeditiously and economically by motor-wagons the industrial situation of the United Kingdom will be materially strengthened. High freight rates, which seem inevitable because of very heavy capitalization of British railways, which was due to the immense cost of their initial construction, are a serious toll on British commerce.

Canal traffic is important and helpful, but very slow. The canals are also small, and many are owned by the railways. Compared to the splendid system of canals in Germany and France, with their low freight rates, the United Kingdom is at a serious disadvantage, and feels it more and more because of German competition for the markets of the world, which becomes more aggressive and keener each year. Then, too, German exporters have the advantage of lower railway rates on merchandise destined for export, while the greater regularity of shipment of foreign goods into the United Kingdom results in what are really better rates on merchandise and food products that come from abroad than are obtained by those destined for export. In these circumstances pronounced demand for the improvement of the British canal system, and even for its nationalization, is not surprising.

If heavy motor-wagons prove successful carriers of freight, the further development and improvement of the canal system will not be so important, railway freight rates will naturally come down, whatever arbitrariness there may be on the part of railways will disappear, and the Kingdom will be in far better position to hold its own in the markets of the world, and even to increase its share of those markets.

There is little reason why the experiment with motor-wagon freight carriers should not be successful. Roads are almost universally good, distances are not great, motor construction is improving and the output increasing, while rates for carriage should remain low because the highways are free. There can, therefore, be no monopoly of the new method of freight transportation which experts have declared would certainly result from the development of motor-wagons.

A Magnetic Indicator of Temperature for Hardening Steel

AN apparatus for indicating the critical point for heating steel to be hardened was described in a paper read by William Taylor before the British Association. Its operation depends upon the fact that at the critical point the magnetic permeability of the steel is changed.

The apparatus consisted of three

similar flat coils of wire placed parallel on a common axis and equally spaced, the inner coil in circuit with a telephone receiver and the outer coil supplied in series with an alternating current, and so connected that at ordinary times no sound was produced in the telephone. When, however, steel was placed between the centre coil and either of the outer ones, the magnetic balance was disturbed and a sound produced in the telephone. The steel was then heated, and when it reached the critical temperature and became non-magnetic, the sound in the telephone abruptly ceased, whereupon the steel was quenched and hardened.

Steels with carbon contents ranging from .7 to 1.35 per cent. were hardened in this way at temperatures which, judged by the eye alone, no skilled mechanic would feel safe in using, while the fine grain shown on fracture, together with the invariable hardness, showed how closely the critical temperature had been obtained. In each case on letting the steel cool so that sound was resumed in the telephone the steel failed to harden, although the fall of temperature was imperceptible to the eye.

Following this experiment, the magnetic indicator attached to a small muffle furnace was constructed, and has been in daily use in a toolroom for several months, where it has served to indicate temperatures for hardening press tools, milling cutters, traps, reamers, and the like, and has established a record during that time in that not a single piece has been lost through warping or cracking in hardening, while the quality of the hardening has been excellent.

The attachment consists of a hardened steel permanent magnet, extended by soft iron pole-pieces into the general form of a horseshoe magnet, the gap of which is in the muffle of the furnace, and is so adjustable that the piece of steel to be hardened may be arranged to fill the magnetic gap. The pole-piece at one side of the furnace is hinged by rocking on the magnet, and is prolonged in such a way as to form a second and alternative magnetic circuit tending to displace the rocking pole-piece and withdraw it from the object being heated.

This, however, so long as the object is magnetic, is prevented; but when its temperature rises to the critical point, and the steel object becoming non-magnetic releases the pole-piece, the latter rocks, and in so doing establishes an electrical circuit by which a bell is rung, giving audible warning to the attendant.

This device has proved of great practical service by making the work of miscellaneous hardening safe and certain in its results. It is noticeable in every case that the temperature at which hardening is thus safely accomplished is visibly lower than that at which a skilled workman would ordinarily harden steel when endeavoring, on the one hand, to avoid overheating, with its resulting brittleness, cracking, and warping, and, on the other hand, the failure to harden, and the certainty that in rehardening these risks of cracking and warping would be multiplied.

An Austrian Surface-Contact System

THE use of a surface-contact system on the Karlsbrucke at Prague was chiefly decided upon from æsthetic considerations, the employment of underground conduits being impossible on account of the small structural thickness of the bridge. The bridge is laid with a double set of rails, and between each pair of rails two sets of metal contacts have been let in. The two contacts, side by side, are about 1 foot 7 inches apart, whilst the distance from pair to pair along the rails is 8 feet. The sets of contacts nearest the center of the bridge deliver the main current, whilst the other sets of contacts are only auxiliary ones.

The cars are arranged both for an overhead trolley line and for the surface-contact system, and for working the latter they are fitted underneath with two lengths of iron rail, which are let down on to the contacts in the roadway when the car reaches the bridge. The bottom surfaces of these rails are arranged as a grid, so that they serve to keep the contacts clean.

As soon as the iron rails have been let down over the contacts an auxiliary current flows from a small four-cell battery carried on the car, through the auxiliary contacts touched, through a corresponding auxiliary relay and a main relay (fixed at the side of the roadway in iron boxes on the bridge parapet), and back to the cells through the running rails. The armatures of the two relays are attracted, and close the circuit for the main current. This flows along a cable from the supply station to the particular relay box, through a fuse, and through the armature of the main relay to a distributing bar.

The armature of the particular auxiliary relay operated provides a path from the distributing bar to the main studs under the car at the instant, and so through the car motors and out at the car wheels. This main current also charges the auxiliary cells. In this way only the main studs actually under the car are alive at any instant, and since these are 8 feet apart, while the collecting rails under the car are 11½ feet long, current is collected at two studs nearly all the time.

The contact studs consist of an interchangeable metal knob screwed into a metal base, and the whole let into asphalt insulation in a cast-iron pot mounted on wooden beams. The stud projects only about 1⅛ inches above the roadway. As soon as the car has moved past a contact, the auxiliary relay allows its armature to be withdrawn by a powerful spring, and so interrupts the main circuit to the motors through the corresponding main contact stud, which thus becomes harmless to passengers.

Should any one of the auxiliary relays fail to act, danger to passengers is prevented by the provision of a brush at the end of the car, which makes contact at the main stud and causes a short-circuit which blows the fuse of the faulty stud and cuts off the current from it, if this has not already occurred. An additional safeguard against any contact remaining alive after the car has passed is required by the authorities, and experiments on the point are in progress.

The cost of construction is more than double that of the usual overhead system, and it remains to be seen whether the arrangement will prove satisfactory under all atmospheric conditions, or whether excessive leakage will occur when the roads are wet.

Telephone service has been established on all freight trains of the Galveston, Harrisburg & San Antonio Railroad between San Antonio and El Paso, in Texas.

It is reported that the Compania Telefonica Mexicana is contemplating the construction of a telephone line from Monterey to Mexico City, a distance of 683 miles.

Application was recently made in St. Louis by the People's Elevated and Open Subway Railroad Company for a franchise for an elevated and subway system.

Students of Purdue University are to build thirteen miles of an electric railway in the vicinity of Chicago.

Electrical and Mechanical Progress

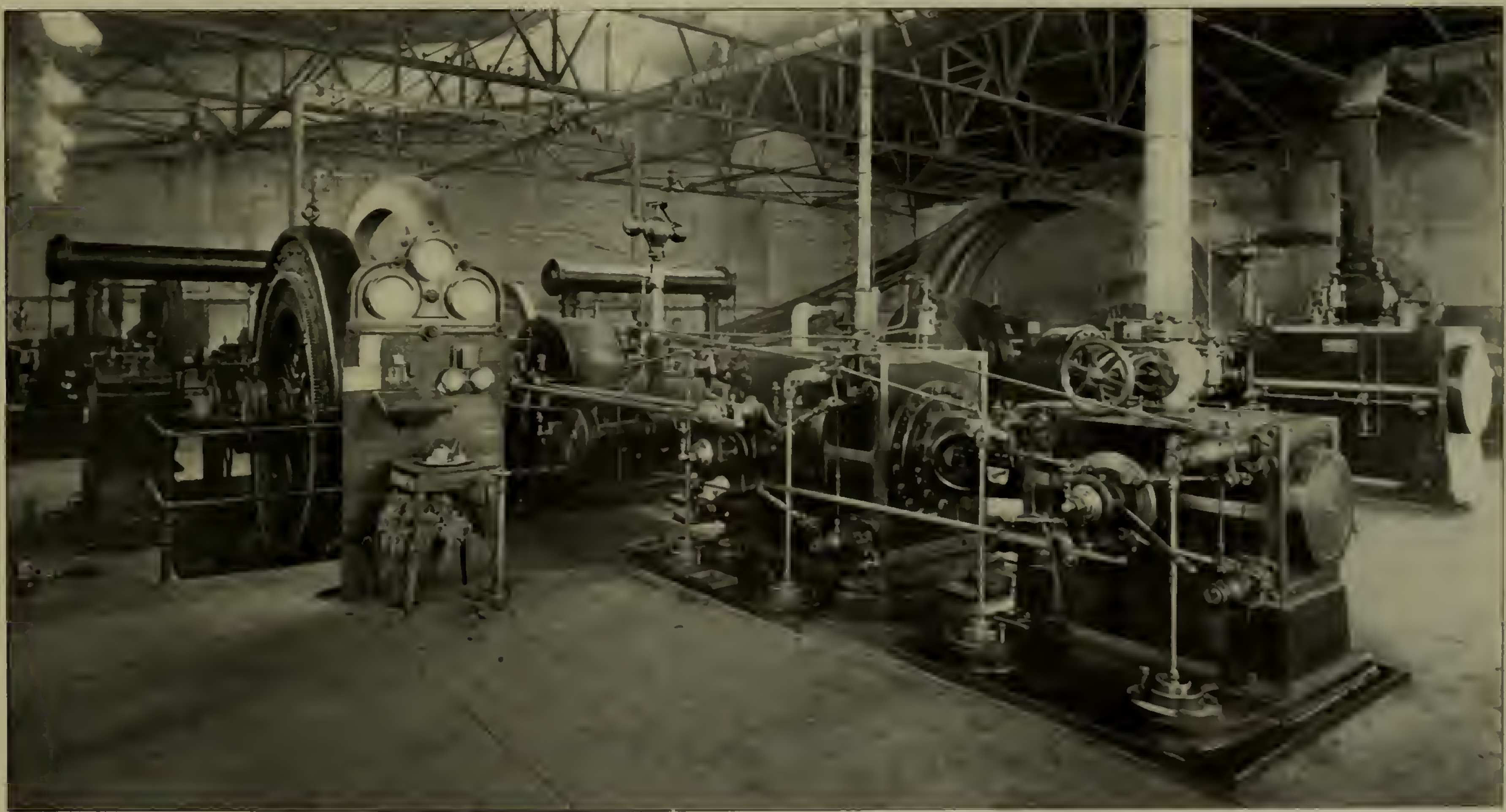
The Electrical Equipment of a Cement Plant

Of the many applications of electric motors in manufacturing establishments there is probably no industry where the power demands are more exacting or the operating conditions more severe than in cement works. The heavy starting torque required by cement making machinery, the nature of the load handled, the constant presence of dust and the inflammability of pulverized coal used in the manufacture of cement, bring up problems in power transmission that require the most careful consideration.

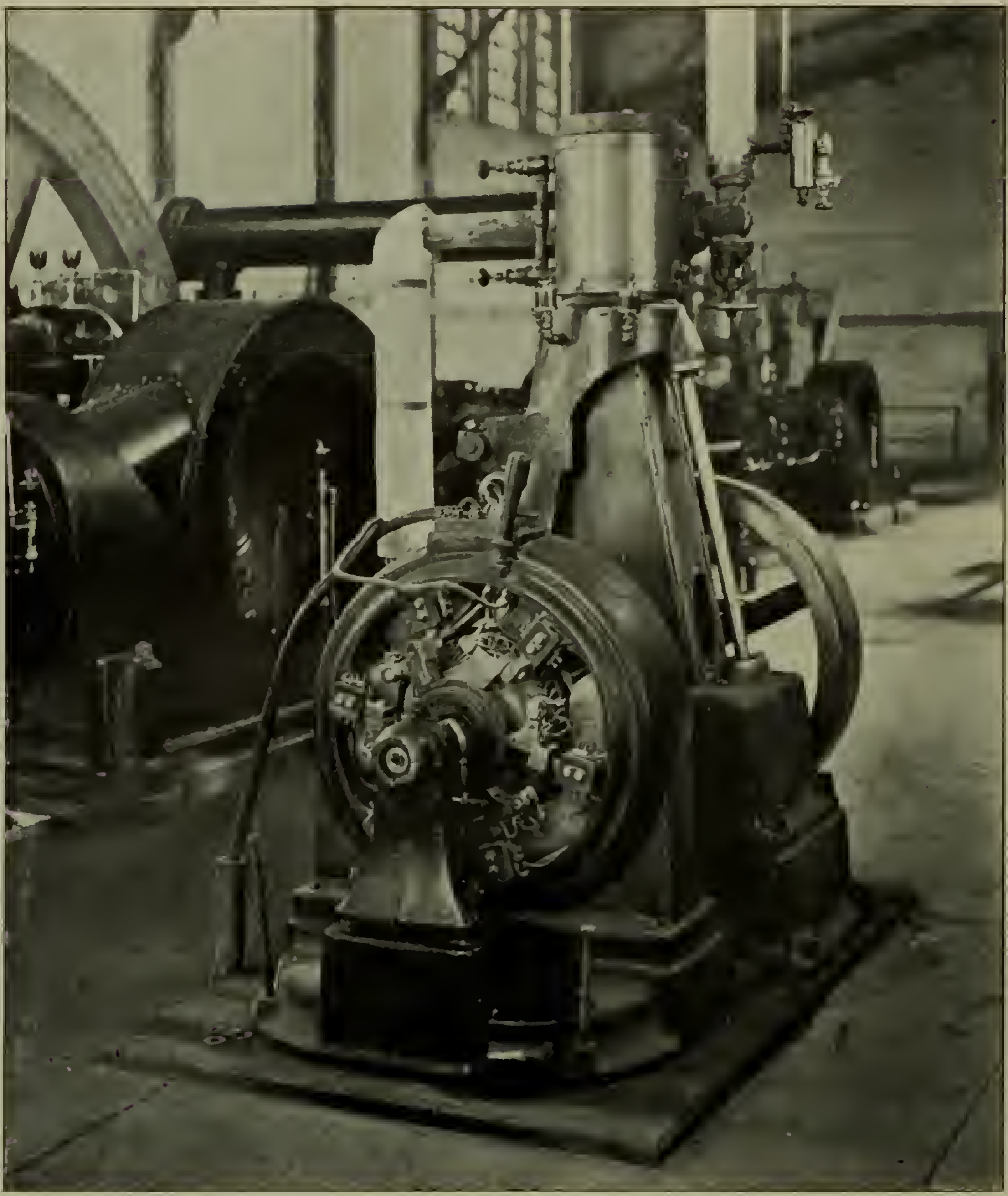
Power transmitted mechanically from a central source is open to many objections not only on account of the loss in long lines of shafting and belting, but the lack of flexibility and the necessity of laying out buildings to conform to such methods of driving add to the complexity of such systems.

These considerations led to a demand for a substitute that would, in the main, eliminate many of the objectionable features referred to and provide a source of power that is immune from fire risk and that can be subdivided and applied at the various points of application. The natural solution of the problem was the adoption of induction motors, which is aptly illustrated by the plant of the Bath Portland Cement Company, at Bath, Pa. This plant was designed for an output of 2500 barrels of cement per day, and is a typical example of modern practice in this industry, the credit for the successful design and operation being due to Frederick B. Franks, superintendent and mechanical engineer of the plant, and James A. Gish, assistant.

The power house is built 10 feet above the ground level, the lower part being used as a basement, which



THE ENGINE ROOM OF THE BATH PORTLAND CEMENT COMPANY, BATH, PA., SHOWING ONE DIRECT-CONNECTED UNIT AND TWO BELTED UNITS



A 10-KW. UNIT FOR FURNISHING CURRENT FOR LIGHTING IN THE PLANT OF THE BATH PORTLAND CEMENT COMPANY

contains steam and air pipes, cables, overflow conduits from condensers and a receiving tunnel from the reservoir. In the boiler room are located eight 300-H. P. Berry boilers. Bituminous coal is used for fuel. The boilers at the present time are hand-fired, but the fronts are so arranged that they can be equipped with automatic stokers.

A reservoir for storing the feed and condensing water is supplied from an artesian well 300 feet deep by a Deming pump operated by a 25-H. P. Westinghouse induction motor.

The engine and generator equipment consists of a 350-H. P. Wetherell-Corliss tandem-compound, condensing engine direct connected to a Westinghouse 200-KW. engine-type, three-phase, 60-cycle, 440-volt generator, and two 1100-H. P. cross-compound engines of the same make, located parallel to each other, and employed to drive the raw mill department and the clinker department. These engines are each fitted with a sheave fly-wheel 18 feet in diameter and $67\frac{3}{4}$ inches face, which drive twenty-two 2-inch transmission ropes connected to sheave wheels on the main line shaft. To this line shaft are belted two Westinghouse 180-KW., 440-volt, three-phase, 60-cycle generators. All three engines are equipped with the Consolidated Engine Stop Company's apparatus, and any unit may be stopped from several places in the works in case of accident.

A small set, consisting of a Westinghouse 10-KW., engine-type, direct-current, 125-volt generator, direct-connected to a Reeves vertical engine, is used for lighting.

A motor-generator set is used for excitation, and consists of a 15-H. P., 400-volt induction motor direct connected to a 10-KW., 125-volt generator.

Two 20-KW., oil-insulated, self-cooling transformers with a secondary voltage of 120 furnish current for forty-eight multiple alternating-current arc lamps and 1500 16-candle-power incandescent lamps.

In order that a clear idea of the manufacture of cement and the various applications of electric motors in such industries may be gained, a description is given here of the various processes from the time the rock leaves the quarry until the cement is packed in barrels.

In the quarry vertical holes are drilled into the solid rock by pneumatic drills, in which the blasting charges are placed and ignited by electricity. The loosened rock is conveyed to the mill in cars by means of gravity and is dumped into two gyratory crushers, where the material is reduced to $2\frac{1}{2}$ inches and under. The empty cars then run to the foot of the incline, where an endless chain, driven by a 10-H. P. induction motor, draws them to the top, and they return to the quarry by gravity. The cars each have a capacity of four tons, and an average of seventeen cars per hour are hauled up the incline.

From each crusher the rock is delivered to a continuous bucket elevator, which raises it to a small hopper. From here the rock empties into two large crushing rolls and is further reduced to $\frac{3}{4}$ inch and under. From the rolls it is elevated on another continuous bucket elevator and emptied into two revolving stone dryers, 72 inches in diameter and 55 feet long, having four compartments in which the stone is dried. An exhauster is used in connection with the dryers, the stack being located on the outside of the building.

From the dryers the stone discharges into a continuous bucket elevator and is delivered into another set of rolls driven by a 100-H. P. motor. From this roll the stone is elevated and delivered into a storage bin in the storehouse or onto a reversible belt conveyor traveling over the top of the stone storage bin. The conveyor carries the stone into the raw mill and delivers it to a belt conveyor which discharges into seventeen storage bins above the grinding mills. The storage bin in the storehouse is of concrete and steel construction, and has a capacity of 1200 tons of crushed stone. The stone is taken from this bin by a belt conveyor in a tunnel beneath and is emptied into an elevator, which, in turn, conveys the crushed stone over the bins in the raw mill. The large storage bin in the storehouse is kept filled to its maximum capacity, as this department operates only ten hours per day, and enough excess material is stored to enable it to close down for three days at least. The machinery in this department is operated from the main line shaft, which is driven from the engine room, as already described.

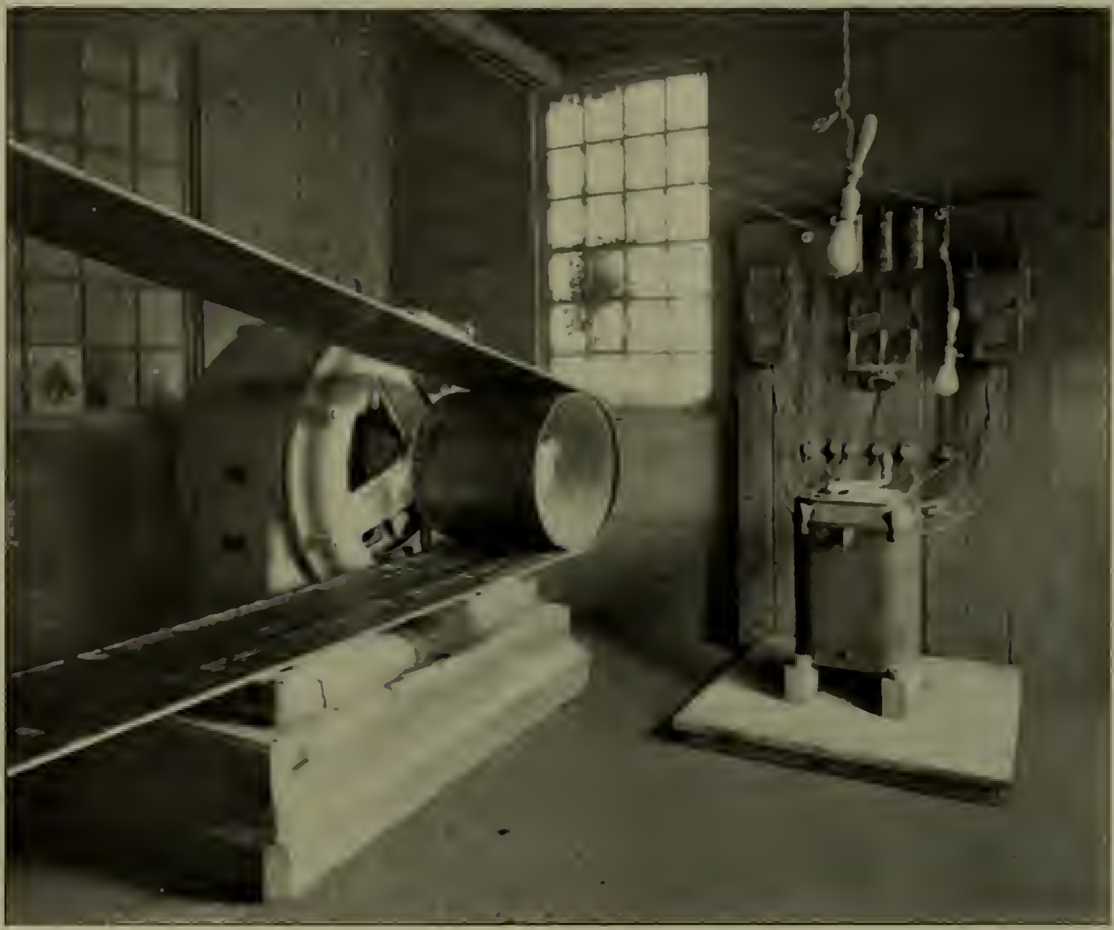
The next process is taken up in the raw grinding room where are located sixteen mills, driven from the same line shaft that operates the machinery in the storehouse, each mill having its independent clutch. Large storage bins are located over the mills, which empty directly into their feed hoppers, ample room being provided for any necessary repairs. Passing through the mill, the material is delivered into a screw conveyor located in a tunnel beside the mill foundation and emptying into an elevator in the kiln house. In this house the machinery is driven by a line shaft belted to a 100-H. P. induction motor, which also drives a 22½-KW., 125-volt exciter, which supplements the exciters in the engine room proper.

The kiln house connects with part of the raw grinding room, and the rotary kilns are placed transversely across the building. There are six kilns, each 100 feet long, 7½ feet in diameter at the large end and 5½ feet at the stack end. The stacks are 60 feet high and 5 feet in diameter. Each kiln is driven from the line shaft by means of a Mosser speed regulator of the interlocking-cone pattern, controlled by a tight and loose pulley that also controls the feeding of the raw material from the storage bins.

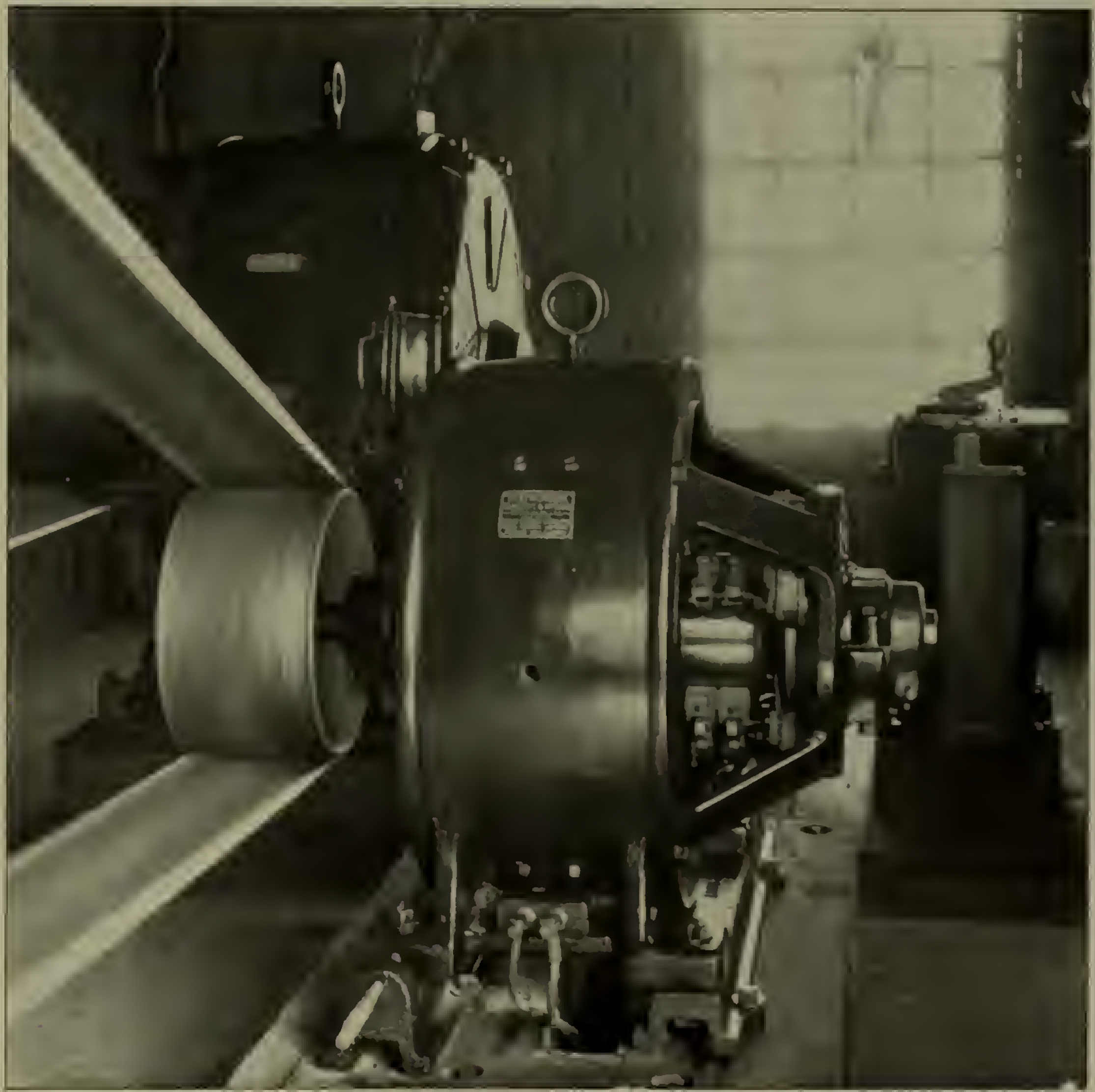
The raw material is raised by an elevator from the raw mill to a screw traveling transversely across the kiln storage bins. Another screw is also used to remove the spill and dust from the dust chambers at the feed end of the kilns, and, in turn, empties into the elevator that receives material from the raw mill. At the delivery end of the kiln the clinker discharges into a pit, forming a chute that empties into three bucket elevators, one elevator being used for two kilns. The clinker is then elevated and discharged into three clinker coolers. The elevators are operated by a 30-H. P. induction motor. The coolers are arranged with spouts, which deliver the clinker into conveying machinery which extends to the clinker storage, where the clinkers are well seasoned before grinding.

Fuel for the kilns consists of pulverized coal, which is forced through pipes from the feeders to burners. The feeders, six in number, are each operated by a 1-H. P. induction motor.

The clinker discharges from the coolers on a belt conveyor traveling through the concrete foundations upon which they rest, the discharge from the cooler being controlled by a hand-operated gate. The first belt conveyor empties into a second belt conveyor, which delivers the clinker to an elevator which, in turn, delivers the clinker to a conveyor distributing from the clinker storage to a belt conveyor. This empties into an automatic measuring device which discharges into a storage bin, the



A 100-H. P. WESTINGHOUSE INDUCTION MOTOR DRIVING MACHINERY IN THE STOREHOUSE



IN THE BACKGROUND IS A 100-H. P. INDUCTION MOTOR OPERATING KILNS. IN THE FOREGROUND IS A 22½-KW. EXCITER

A MOTOR-DRIVEN KILN. THE PIPE EXTENDING INTO THE OPENING IN FRONT IS FOR FEEDING PULVERIZED COAL

latter feeding three pot crushers.

An automatic gypsum measuring device is used and arranged so that a continuous flow of this ingredient enters and mixes with the clinker before crushing. From the pot crushers the clinker is conveyed by belt and emptied into a second conveyor that discharges into an elevator delivering the material in the clinker-grinding room. The unfinished clinker storage room will have a capacity of 100,000 barrels, with provision for increasing the amount if necessary.

Three tunnels will be used which contain the belt conveyors, the feeding of the clinker being controlled by the Link Belt Engineering Company's system of under-cut gates.

A COAL FEEDER OPERATED BY AN INDUCTION MOTOR

These conveyors will empty into another conveyor, where the material is delivered to an elevator emptying into a measuring device located in a bin connected with the pot crushers.

The clinker, after passing through the pot crushers in the clinker storage house, enters the clinker-grinding room on a belt conveyor and is emptied into a bucket elevator and conveyed to two sets of clinker-crushing rolls, where the clinker is reduced to about the size of peas and then elevated and conveyed to bins over mills in which it is ground to cement. After the clinker-grinding room comes the cement stock house where the finished product is stored. From the former department, cement screws empty into a bucket elevator that elevates and delivers into an overhead screw operating right and left. This, in turn, discharges into two screws traveling longitudinally with the building, one of them emptying into a large bin on one side of the building and into a number of smaller bins on the opposite side, where a screw conveyor in a large tunnel delivers the cement to the packing house. From the large bin a screw conveyor also delivers cement to the packing house. All the machinery in the stock and packing house is operated by a 100-H. P. induction motor.

The coal pulverizing plant, where the coal for the kilns is prepared, contains a self-contained coal dryer, a crushing roll, and four mills for pulverizing the coal. After passing through the dryer the coal is delivered by a screw conveyor into the crushing roll, then into a bucket elevator that empties into a screw conveyor above the storage bins for the mills. After passing through the mills the coal is delivered by means of a screw conveyor and an elevator to the coal bins in front of the kilns. All the machinery in this department is driven by a 200-H. P. induction motor.

A modern machine shop, operated by a 10-H. P. induction motor, where all repairs are made, completes the equipment of one of the most modern and complete cement plants in this country.

A Motor-Driven Window Display

An interesting application of the electric motor to advertising purposes is shown in the annexed illustrations. It is of value to the central station man as suggesting a way, other than the use of electric lights, signs, etc., for the customer to use electric current for advertising his business.

A TRAVELING WINDOW DISPLAY IN THE STORE OF A CLEVELAND MERCHANT. THE APPARATUS IS DRIVEN BY AN ELECTRIC MOTOR BENEATH

The apparatus illustrated is used by an enterprising Cleveland merchant to multiply his available window display space by four,—a seeming impossibility.

This is how he did it: The window floor was arranged so that it revolved like an endless chain over two drums at either end, the window floor extending back into the store the depth of the window and being separated by a black velvet cloth.

The various aluminum articles,—about 200 in number,—were wired to the moving window floor, and thus produced such a unique and striking effect as to challenge the attention of large numbers of pedestrians. Before this device was installed but fifty pieces could be shown, and that in the old-time, stationary style. This enterprising merchant has "blazed a new trail" in the window display line which merchants in many other lines of business may find it to their advantage to employ.

The device was home-made, simple in design, inexpensive, and driven by a small electric motor concealed below the floor.

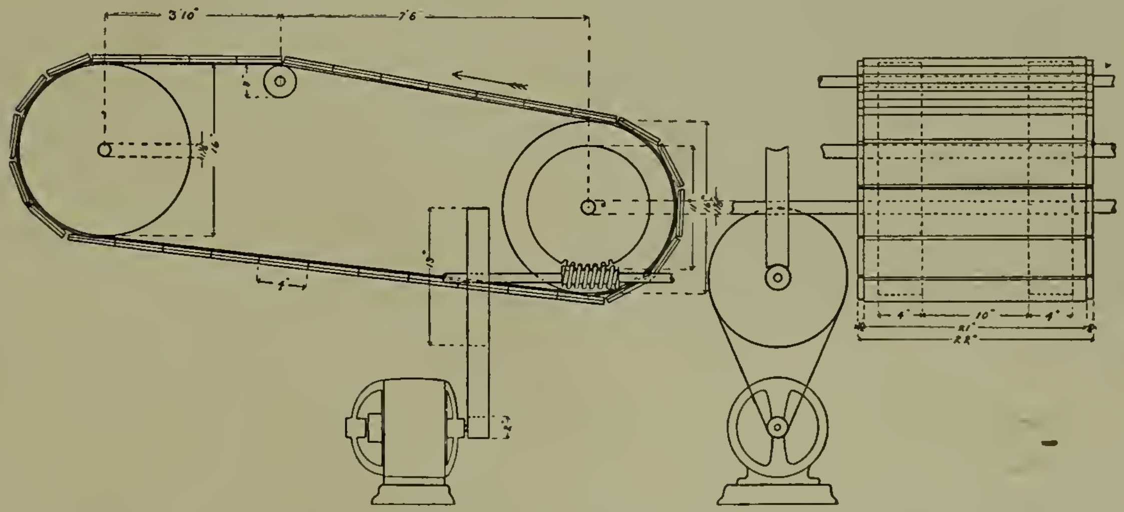


DIAGRAM SHOWING ARRANGEMENT OF THE APPARATUS FOR THE TRAVELING WINDOW DISPLAY ILLUSTRATED ABOVE

Oil-Insulated Transformers

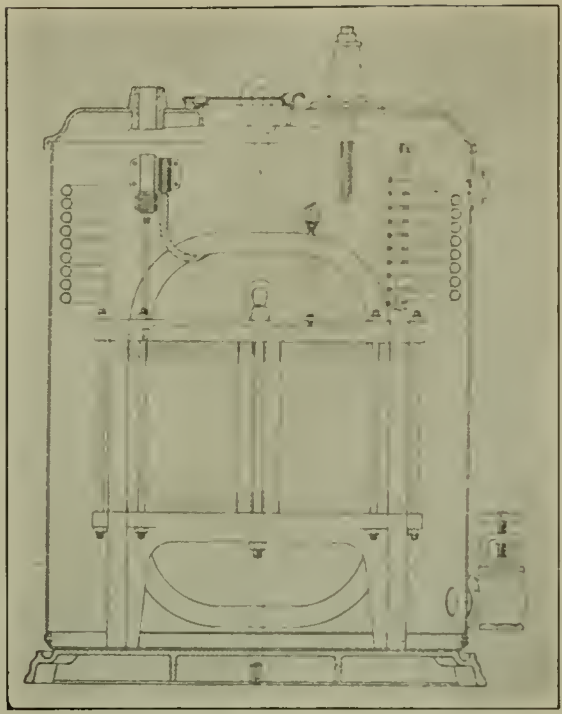
OIL-INSULATED transformers, built by the Allis-Chalmers Company, of Milwaukee, Wis., are shown in the annexed illustrations. The self-cooled transformers are built in sizes up to 300 KW. Above this size the external surface of the case is not sufficient to radiate the heat developed in the transformer core and coils, unless the enclosing tank is made abnormally large. The water-cooled transformers are made in sizes from 100 KW. up. Water is circulated in a coil of seamless copper or brass tubing immersed in the oil, and the heat is effectively carried off.

Whenever the water is available and not expensive this method is preferable to air-cooling, even with comparatively small transformers, as it permits operation at lower temperatures and allows more margin for overloads.

A 500-KW., 405-2000-VOLT, OIL-FILLED, WATER-COOLED TRANSFORMER, BUILT BY THE ALLIS-CHALMERS COMPANY, MILWAUKEE, WIS.

Where water is not available, there is a choice of two kinds of air-cooled transformers, namely, the oil-filled, self-cooled type and the air-blast type, which is cooled by a forced circulation of air through the core and coils. Air-blast transformers, however, are unreliable for pressures much above 25,000 volts.

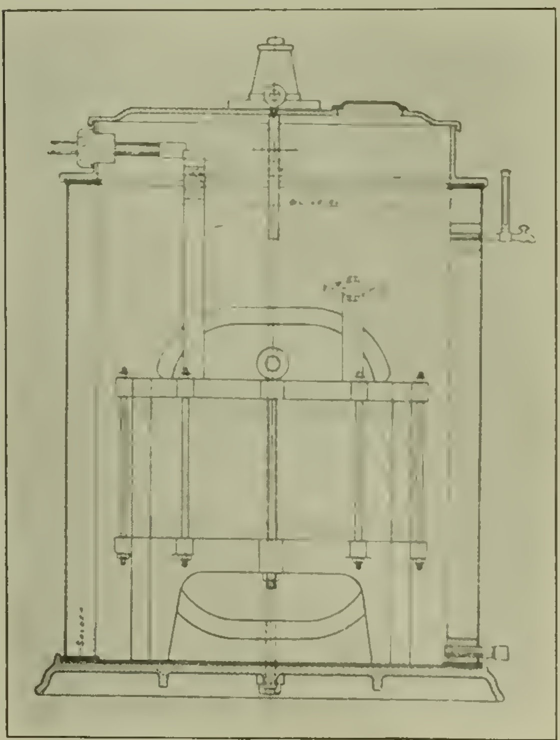
The oil-filled, water-cooled transformers are placed in boiler plate tanks, cylindrical in form, and provided with a substantial cast-iron base and cover. The tanks, which are riveted and calked, are supplied with eyebolts extending from the cover to the base, so that the transformers, as a whole, can be lifted without straining the tank. The cooling coils are made of 1¼-inch tubing, without joints throughout



SECTIONAL VIEW OF AN OIL-FILLED, WATER-COOLED TRANSFORMER

the portion immersed in the oil; all coils are tested with a water pressure of 200 pounds per square inch.

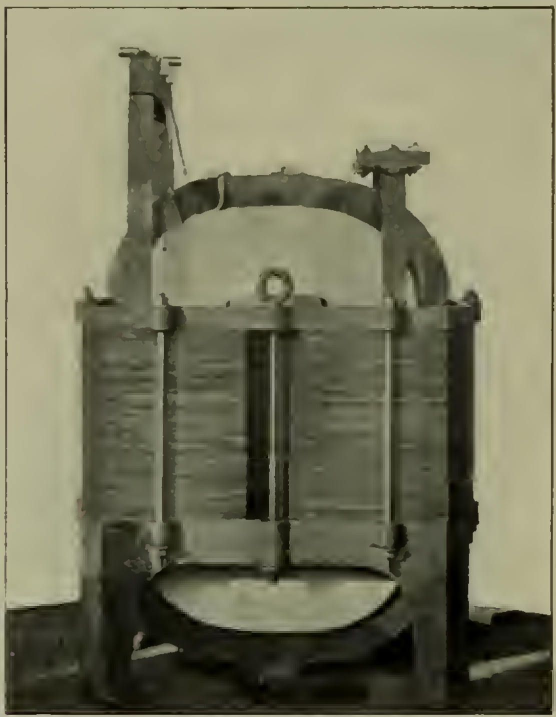
With coils constructed in the usual manner it is very difficult to drain all the water from them, and trouble has been caused in some cases by water freezing and bursting the pipe. This has usually occurred either during shipment or some time before the transformers have been placed in operation. In order to avoid this, and also the danger of condensation on exposed parts not covered by oil, the ends of the cooling coils in these transformers are brought out through stuffing boxes arranged below the surface. The lower end is thus below the level of the lowest coil, so that all water can be easily drained off. The coils are permanently fastened to the case, and are of such



SECTIONAL VIEW OF AN OIL-FILLED, SELF-COOLING TRANSFORMER

diameter that the transformer can be lifted out without disturbing the coils or water connections. Water-cooled transformers are supplied with an oil gauge, drain valve, and thermometer, with contacts for an electric alarm attachment that gives a signal in case the temperature exceeds the allowable limit.

For self-cooled transformers, the case is made of terne sheet formed into a cylindrical tank with deep corrugations that present large radiating and cooling surface. The tank has a double bottom made of two flanged pieces of sheet iron riveted together, and the cylindrical corrugated part is soldered into the annular channel-shaped space between the flanges, thus making a tank that is perfectly oil-tight. The tank is provided with a substantial cast-iron base and cover, a lid being placed on the latter to allow inspection and give access to

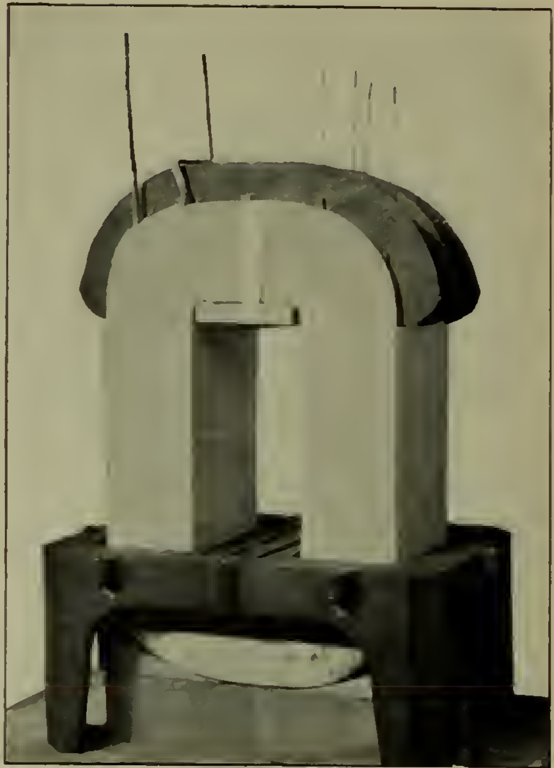


CORE AND COILS OF AN ALLIS-CHALMERS OIL-FILLED TRANSFORMER

the terminal board in case it is necessary to make any changes in the connections.

All transformer coils are wound with double cotton-covered strip copper, one turn per layer, with fullerboard insulation, in addition to the cotton covering, between turns. Exceptions to the foregoing are made only when the size of the conductor is so small as to make this construction impracticable, and in such cases the coils are wound with round double cotton-covered wire with a few turns per layer, so that the voltage between layers is kept within safe limits.

The primary and secondary windings are subdivided into a number of these flat coils, which present large cooling surface to the oil. When the coils are assembled the primary



ASSEMBLED COILS OF AN ALLIS-CHALMERS OIL-FILLED TRANSFORMER

and secondary sections are interleaved, as shown, in order to reduce magnetic leakage and secure good voltage regulation.

When the conductor is large, several strips are used in parallel and insulated from one another to prevent eddy currents. The coils are neatly and tightly bound with extra long linen tape, and no varnish or insulating compounds are used on the windings. Such materials deteriorate with continued use in hot oil, and in many cases are the cause of a deposit on the water-cooling coils or on the bottom of the transformer.

The transformer core is built up of selected sheet steel 0.014 inch thick. The steel is the best obtainable, and is thoroughly annealed, insuring uniform material and excellent magnetic qualities. The laminations are thoroughly insulated from one another by a coating of varnish, which reduces the eddy current loss to a minimum. The steel is of such good quality that it is practically non-ageing, i. e., the core loss does not appreciably increase under long continued operation. There is no steel which will not age slightly when subjected to temperatures above 75 degrees C.; but with normal load and temperature the core loss in these transformers is guaranteed not to increase, within one year, to such an extent as to decrease the full load efficiency more than one-tenth of 1 per cent.

In larger sizes space blocks are placed every few inches in the core, thus providing ducts through which the oil can circulate and carry off the heat.

The oil used in these transformers is a special grade selected after long and careful tests; it contains no acid, has very slight evaporation at 100 degrees C., and its flashing point is about 190 degrees C. or 375 degrees F. It is a thin oil that circulates rapidly throughout the transformer, thereby quickly carrying off the heat; its insulating qualities are excellent.

Personal

Dr. Samuel Sheldon, president of the American Institute of Electrical Engineers, and professor of physics and electrical engineering at the Polytechnic Institute, Brooklyn, N. Y., recently received the honourary degree of doctor of physics from the University of Pennsylvania upon the occasion of the dedication exercises of the University's new engineering building. Dr. Sheldon has been at the head of the electrical and physical departments of the Polytechnic since 1889.

W. H. Blood, Jr., of 84 State street, Boston, has been retained by the National Electric Light Association as insurance expert in the interests of the members. Any member companies having insurance troubles would do well to call upon Mr. Blood for services that will undoubtedly be of great assistance and will be promptly rendered.

Prof. H. E. Clifford, of the Massachusetts Institute of Technology, who has temporarily been directing the affairs of the electrical engineering department, will now be relieved from this executive work, through the recent appointment of Prof. Jackson to the electrical engineering department, and is planning to devote considerable time to consulting engineering.

Louis H. Frick, of Denver, Col., has been appointed general manager of the Cheyenne Light, Fuel & Power Company, which is owned by the Northern Colorado Power Company. Mr. Frick succeeds N. D. Miner, who has resigned.

Stanley Gaines has been appointed superintendent of the Wilson Electric Company, of Huntingdon, Pa. The company furnishes light for the towns of Huntingdon, Petersburg and Alexandria. Mr. Gaines resigns as superintendent of the Citizens' Electric Illuminating Company, of Wilkesbarre, Pa., to take up his duties with the Wilson Electric Company.

C. W. Hutton, formerly superintendent of the Sacramento Electric, Gas & Railway Company, has been promoted to the position of superintendent of the Sacramento division of the California Gas & Electric Corporation. He will have general charge of power houses and transmission lines.

John H. Merrill, secretary of the Central Electric Railway Association, has resigned to accept the position of general manager of the Choctaw Electric Railway & Lighting Company, of McAllister, Okla. William F. Millholland, treasurer of the association, will fill out Mr. Merril's unexpired term, which will end next January.

H. C. Abell, manager of the interests of the Muskegon (Mich.) Traction & Lighting Company, has been appointed general manager of the American Light & Traction Company's property at Long Branch, N. J., known as the Consolidated Gas Company. He will move to Long Branch, but will make frequent visits to Muskegon as president of the Muskegon Traction & Lighting Company.

The following changes in the electrical engineering staff of the New York Central Railroad were recently announced:—Edwin B. Katte has been appointed chief engineer of electric traction. George A. Harwood has been appointed chief engineer of electric zone improvements, exclusive of electric traction and signals. John D. Keiley has been appointed electrical engineer, and Carl Schwartz engineer of power stations.

Trade News

The illustrated lectures which A. J. Marshall, illuminating engineer of the Holophane Glass Company, of New York, is giving before the central stations and gas companies on the question of light and illumination, are proving very successful, and it is expected that this work will be the means of greatly assisting the growing demand for the best kind of lights properly placed for desired effects. Mr. Marshall lectured before the West Penn Electric Company, at Connellsville, Pa., on Thursday evening, October 25, at which an enthusiastic audience displayed great interest. The Holophane Glass Company wishes to announce in connection with this that while this lecturing is planned out for some time ahead, they will, nevertheless, be pleased to consider application for this kind of work and deliver lectures in the order that requests are received.

Dossert & Co., of New York, announce that they have received notice from their representative in Milan, Italy, that the Dossert solderless connectors exhibited at the Universal Exhibition at Milan were awarded a gold medal.

A system of window illumination that has been adopted by every large department store in New York City must, of necessity, have established a claim to all the desirable elements in that most important field. The special patent window reflector manufactured by I. P. Frink, of 551 Pearl street, New York, is the device which has this enviable record. To it, it is claimed, more than any other factor may be credited also the brilliant appearance of the retail centres in cities and towns throughout the country. Some recent orders were for lighting the show-windows of B. Altman & Co., James McCreery & Co., Lord & Taylor, New York City; the May Company, Denver, Col.; Watt, Rettew & Clay, Roan--oke., Va.; H. Astrich, Harrisburg, Pa.; Hutzler Bros., Baltimore, Md.; W. D. Kinsman Company, Springfield, Mass.; D. J. Donahue Company, Missoula, Mon.: M. S. Plaut Company, Danville, Ill.; Sibley, Lindsay & Curr, Rochester, N. Y.; Julius Sycle Sons, Richmond, Va. Central stations and contractors who are after new business have found the Frink reflectors a material aid to their efforts. These reflectors are becoming better known by a very thorough campaign of advertising to the possible users, all of which is a direct benefit to the electrical trades.

The permanent organization of the Wilkinson Steam Turbine Company, of Providence, R. I., has been effected, and arrangements for putting its products on the market are being completed. It will build steam turbines and allied machinery under the inventions of James Wilkinson, formerly of Birmingham, Ala. These inventions are said to apply to a wide range of turbine improvements, protected by a great number of United States and foreign patents which broadly cover systems of construction, of operation, and of regulation, as well as numerous detail improvements in many of the features essential to a first-class turbine, and to advance in that field beyond present practice. It is believed by the promoters of this company that the Wilkinson systems and patents cover the lines upon which the advance of the steam turbine beyond present accomplishment must be made, both in marine and stationary practice, and in all other countries as well as the United States. The Wilkinson turbine will be built at the Corliss Steam Engine Works, Providence, R. I., and the executive office of the company is at that place. New York and other offices will be established in due season. Edward K. Hill is president of the company.

The Century Electric Company, of St. Louis, Mo., announce that the demand for their single-phase, self-starting, vertical motors for direct connection to centrifugal pumps, etc., which have been on the market for a year, has far surpassed their most sanguine expectations. It seems that this vertical type is becoming more popular all the time. The company is making them not only for supporting by feet, as is usual of this type of motor, but also so they may be bolted to any vertical ercises of the university's new en-support.

The International Jury of the Milan Exposition has just announced the award of a Diploma d'Onore to the "Long Arm" system of electrically operated bulkhead doors. The award takes higher rank than the gold medal granted by the jury in some cases. The "Long Arm" System Company, of Cleveland, Ohio, had an elaborate installation of its water-tight doors at the Exposition, and so much attention was attracted by the exhibit as to give rise to a demand upon the government to make the installation of electrically operated bulkhead doors on large passenger ships obligatory. Some time ago the "Long Arm" system passed the severe tests put upon it by the United States Navy Department, and the electrical doors and hatches of this system are now in use upon most of the new American warships. From a central emergency station above deck all the principal bulkhead doors can be closed in a few minutes. The great advantage gained is that the electrical control makes closure of the doors possible under all circumstances, even in the event of a hull puncture below the water line, or when the conditions would make it impracticable to close bulkhead doors by hand against inrushing water.

New Catalogues

A bulletin recently sent out by the Electric Storage Battery Company, of Philadelphia, deals with the installations of "chloride accumulators" for the Columbus Railway & Light Company. The illustrations show the equipment installed, and reproductions of voltmeter charts show the regulation obtained by means of the battery.

Electric blue-printing machines manufactured by the Buckeye Engine Company, of Salem, Ohio, are illustrated and described in a pamphlet recently issued. The tracing and paper are placed in a cylindrical frame at the centre of which hangs an arc lamp. The outfit is compact and convenient, and should find a place in every shop where this work cannot wait upon the brightness of the sun.

A new pamphlet sent out recently by the Fostoria Glass Specialty Company, of Fostoria, Ohio, is devoted to "noblac" inner globes for arc lamps. The illustrations show different departments of the company's works, and dimensional drawings are also given of the various types of inner globes made for the arc lamp manufacturers.

Portable testing sets for every purpose are dealt with in a pamphlet sent out recently by Queen & Co., of Philadelphia. The various types are illustrated and the particular use of each explained.

Single-phase motors built by the Century Electric Company, of St. Louis, Mo., are illustrated and described in a recent pamphlet. These motors are of the self-starting, commutator type, and are built for both constant and variable speed.

A catalogue of electric railway supplies was sent out recently by the General Electric Company, of Schenectady, N. Y. The book is bound with board covers, and, with its 233 pages and numerous illustrations, makes quite a pretentious publication.

Water-cooling towers built by the De La Vergne Machine Company, of New York, are illustrated and described in a folder recently issued. A sectional view shows the construction of the tower.

Pulverizers and crushers for a variety of purposes are illustrated and described in an attractive pamphlet sent out recently by the Jeffrey Manufacturing Company, of Columbus, Ohio. The illustrations show the machines assembled and in partial detail. Some of the other products of the company,—screens, cars, elevators, conveyors, rock drills and electric locomotives and dump cars,—are also illustrated.

Some of the engineering work of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, is illustrated in a pamphlet recently sent out. The views show industrial plants, office buildings, iron and steel plants, and the hydro-electric power station for the Chicago Drainage Canal. The scope of the work of the company is fully dealt with.

A series of bulletins sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind., are devoted to integrating switchboard wattmeters, switchboard panels for multiphase generators, multiphase induction motors, and the equipment for the multiple alternating-current street arc light system.

"Steam Traps" is the title of a pamphlet recently sent out by the Joseph Dixon Crucible Company, of Jersey City, N. J. The text is by W. H. Wakeman, and the various types of traps are illustrated and their various features explained.

Christensen air-brake equipments manufactured by the Allis-Chalmers Company, of Milwaukee, Wis., are illustrated and described in a recent pamphlet. The various parts of the equipment are illustrated and numbered, the name of each part being tabulated with its number. The main parts of the equipment are also described.

Electrical Development in Bombay

WRITING under recent date from Bombay, India, Special Agent Chas. M. Pepper says that electrical installation in that city has just begun. Several years ago the Boston capitalists who owned the tramway system proposed the change from horses to electric traction and to provide power for a variety of purposes. A local English official, who was strongly opposed to American enterprise, succeeded in blocking an agreement with the municipality which would have enabled this to be done. Finally the Americans closed out their interests and the work was undertaken by a British company, which, after several years, is just getting into shape to supply power. At present not more than 200 electric fans are in use in Bombay, but their number will be largely increased. The business of supplying hotels, bungalows, etc., with small electric plants appears to be in the initial stage.